NASA Contractor Report 3316

Modular Antenna Design Study

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PREFACE

This report documents the findings of a study funded as Subtask 14 of Contract NAS1-14887. The study researched the mechanical design of a modular antenna concept using a particular deployable module concept. The design was developed sufficiently to allow manufacture of a working demonstration model of a module, and to predict mass properties and to make performance estimates for antenna reflectors composed of these modules.

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1.0 INTRODUCTION

Within the aerospace community, many ways are currently being investigated to assemble, erect, or deploy large reflector surfaces in space. One concept, potentially applicable to the construction of reflectors up to several hundred meters in diameter and embodying several desirable features, consists of individual deployable modules which are assembled in orbit into the final structural configuration. The primary features of this concept are: 1) each module is an autonomous structural element which can be attached to adjacent modules through a three point connection; 2) the upper surface is a folding hexagonal truss plate mechanism which serves as the supporting substructure for a reflective surface; and 3) the entire truss and surface can be folded into a cylindrical envelope in which all truss elements are essentially parallel. The folded module is only 25 cm in diameter and when a full bay length of 17 m is used the deployed module is 24 m across flats. The modules are transported in the folded position, individually deployed on-orbit, and assembled into the required structure.

The initial effort described in this study has accomplished demonstration of concept feasibility through development of a subscale engineering model. This model possesses all mechanical working features such as folding joints, module attachment points, deployment mechanisms, and surface attachment methods characteristic of a full size module.

The development activity has indicated that this deployable modular approach toward building large structures in space will support erection of 450 m apertures for operation up to 3 GHz with a single Space Shuttle Flight. Multiple launches will provide unlimited aperture size capability to the limit of efficiency dictated by the use and maturity of full space

erection or space fabrication techniques. The modular concept is compatible with the incorporation of secondary structure for the reflecting surface as well as active surface control systems. Addition of these elements provides the potential for operation of these large structures in the mm wave region.

Use of trade names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration.

2.0 MODULE DESIGN DESCRIPTION

2.1 Module Structural Arrangement

The general arrangement of the modular concept is shown in Figure 1. Each module is made up of small diameter (1.27 cm), thin wall (.4 mm) tubes which are hinged so as to stow as a cylindrical package approximately 25 cm in diameter by a length of about 5/8 the diameter of the deployed modular segment. The module deploys into a space frame structure with a truss supported hexagonal reflective mesh front surface and a triangular rear support frame connected to the front surface by cross braces. Each module is of a depth equal to .86 times the diameter across the corners of the hexagon.

Figure 2 shows the demonstration model at several points in the deployment sequence. Deployment is achieved by operating a jackscrew mechanism located at the center of the module which separates the center pivots of the two sets of radial arms in the upper surface truss. During this motion the arms rotate outward and downward to deploy the surface. The perimeter arms, which are hinged at the center and folded parallel to the upper radial arms in the stowed position, are allowed to deploy by the deploying radial arms. The deployment energy for the perimeter arms is obtained from springs within the center fold joint, as seen in Figure 3. When the arm reaches its fully deployed position (straight), this spring activates a latch locking the arm into the open position. Thus the six perimeter arms form, when deployed, a rigid hexagonal outer hoop.

The rotation of the jackscrew shaft also pays out cables from drums which allow the cross braces and lower structure to deploy. The deployment forces for deployment of these members are supplied by spring loaded joints located at the mid-span fold joints of each set of cross braces

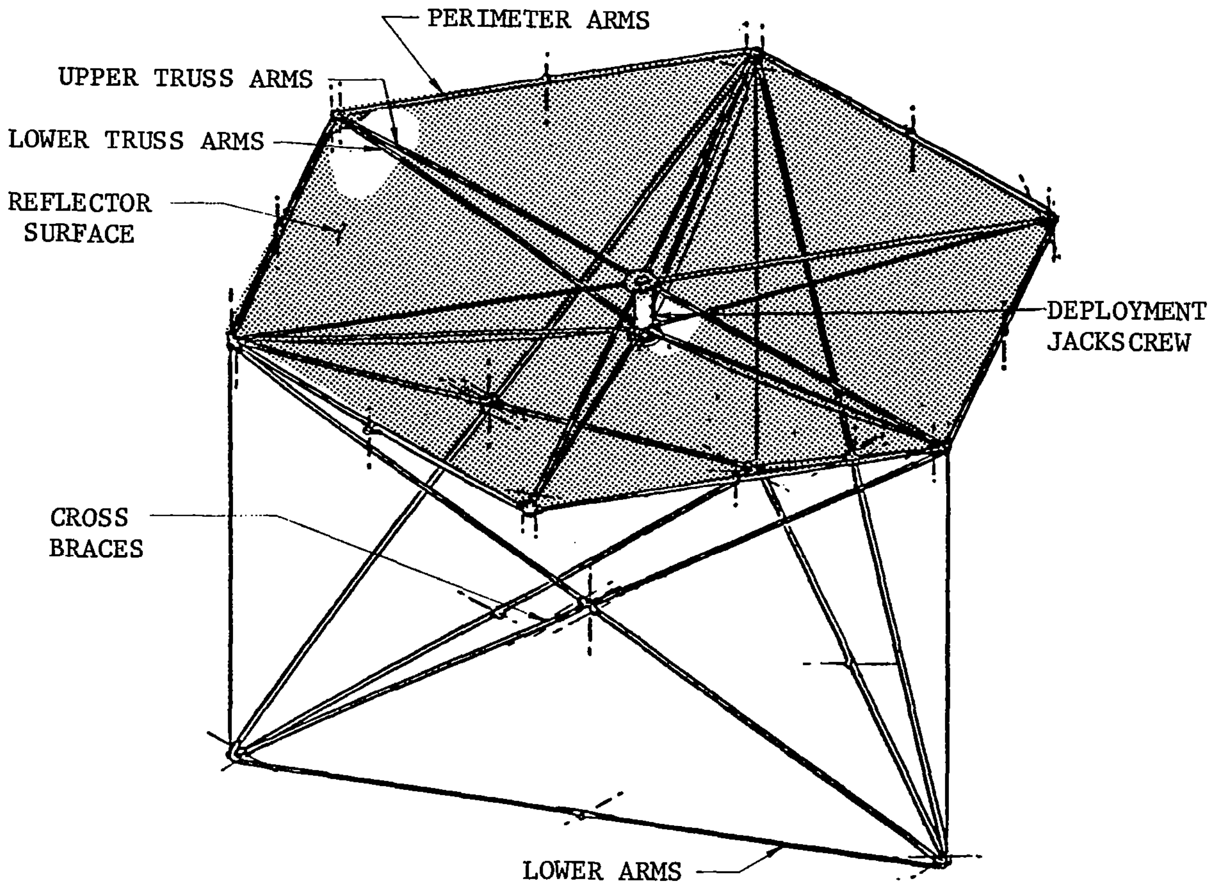
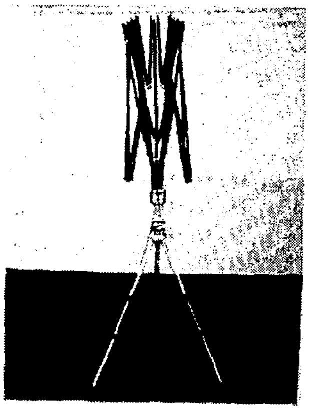
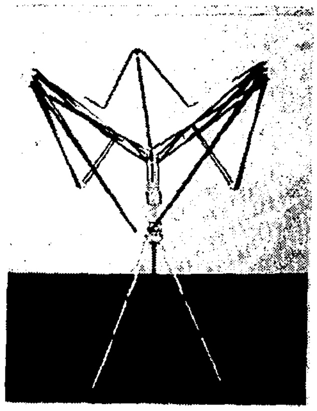


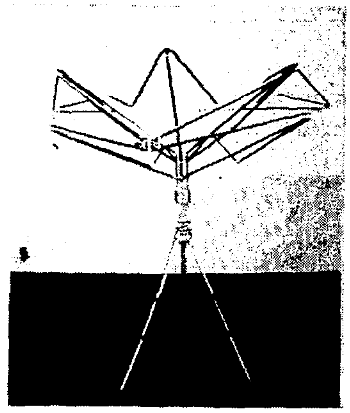
Figure 1. General Arrangement, Deployable Module.



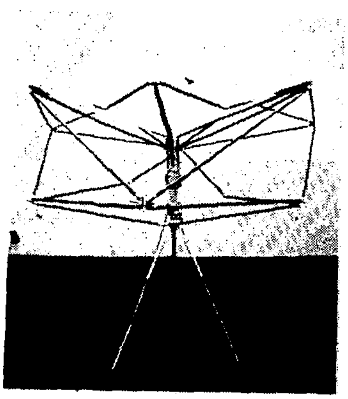
A) Stowed



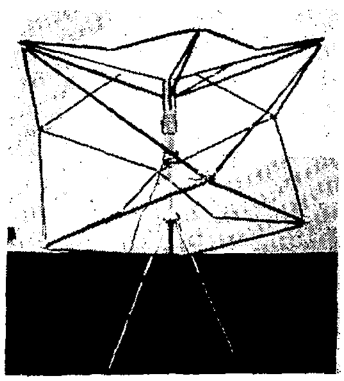
B) ≈ 10 Seconds into Deployment



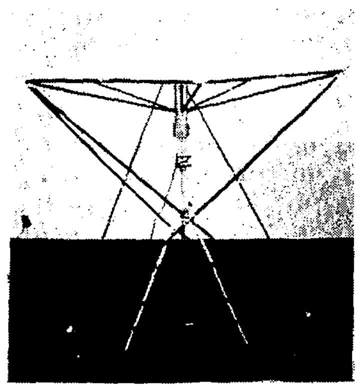
C) After Raising Cross Brace Pivots



D) ≈ 1/2 Deployed



E) ≈ 3/4 Deployed



F) Fully Deployed

Figure 2. Deployment Sequence - Demonstration Model.

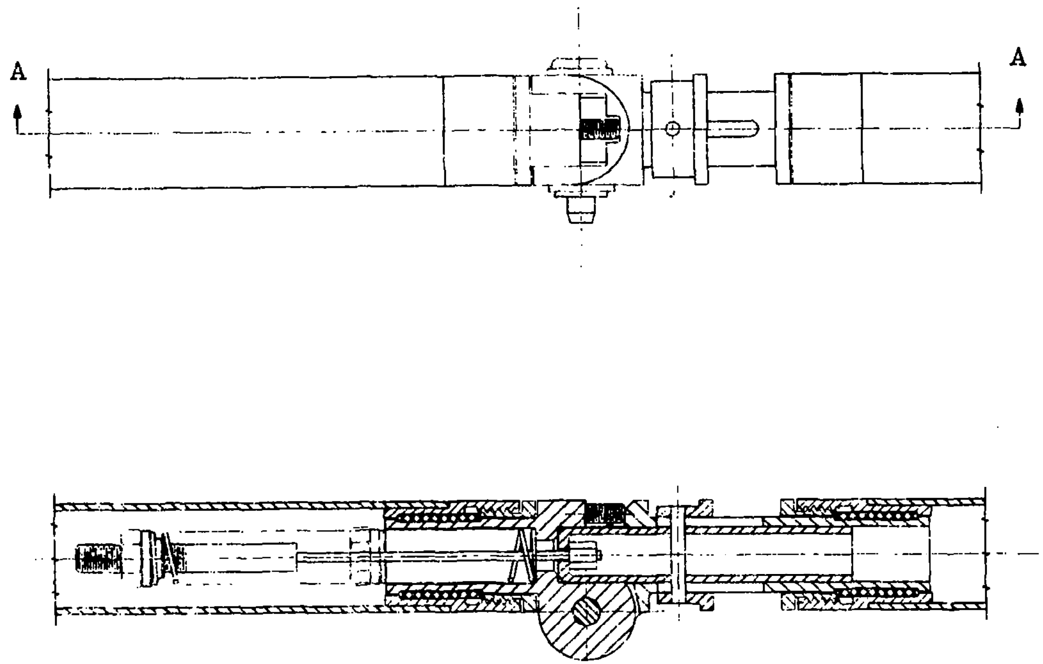


Figure 3. Center Fold Joint, Perimeter Arm.

and the center fold joint of each bottom frame member. Each of these springs also operates a latch to lock the joint in its fully deployed position. The cable spool pays out slightly more cable than required for the deployment motion to insure that there is no residual cable tension in the deployed module.

2.2 Kinematic Description

2.2.1 Front Surface Description. The front, or reflective surface support, face of the module is made up of six equally spaced radial four bar linkages and an outer perimeter ring made up of six singly folded arms. Figure 4 displays the kinematic motion for one of the radial linkages. As can be seen, the motion of each of these links is straightforward. Figure 5 depicts the motions of one of the perimeter arms and Figure 6 details the torsional rotation requirements of the mid-beam joint. It can be seen from the diagram that the links must accommodate 60° of relative pivot axis rotation during deployment. Furthermore, since the pivot axes of joints B and C of Figure 6 must be normal to the centerlines of the links (in order for them to stow parallel), and the mid-beam pivot must remain in a radial plane, there is only one stress free kinematic solution. The end pivot axes are chosen parallel to each other and the mid-beam pivot and torsional joint are incorporated into each link at the mid-joint to allow the required torsional freedom. Using this configuration allows a minimum stowed radius (since the tubes can be arranged essentially in a circle) allows the beam end fittings to be identical to those used at the inboard end of the upper and lower radial arms, and allows the centerlines of the deployed perimeter arms, upper radial arms, and lower radial arms to intersect at single points located at each of the six corners of the deployed hexagonal surface, providing for direct, axial load paths in the beams.

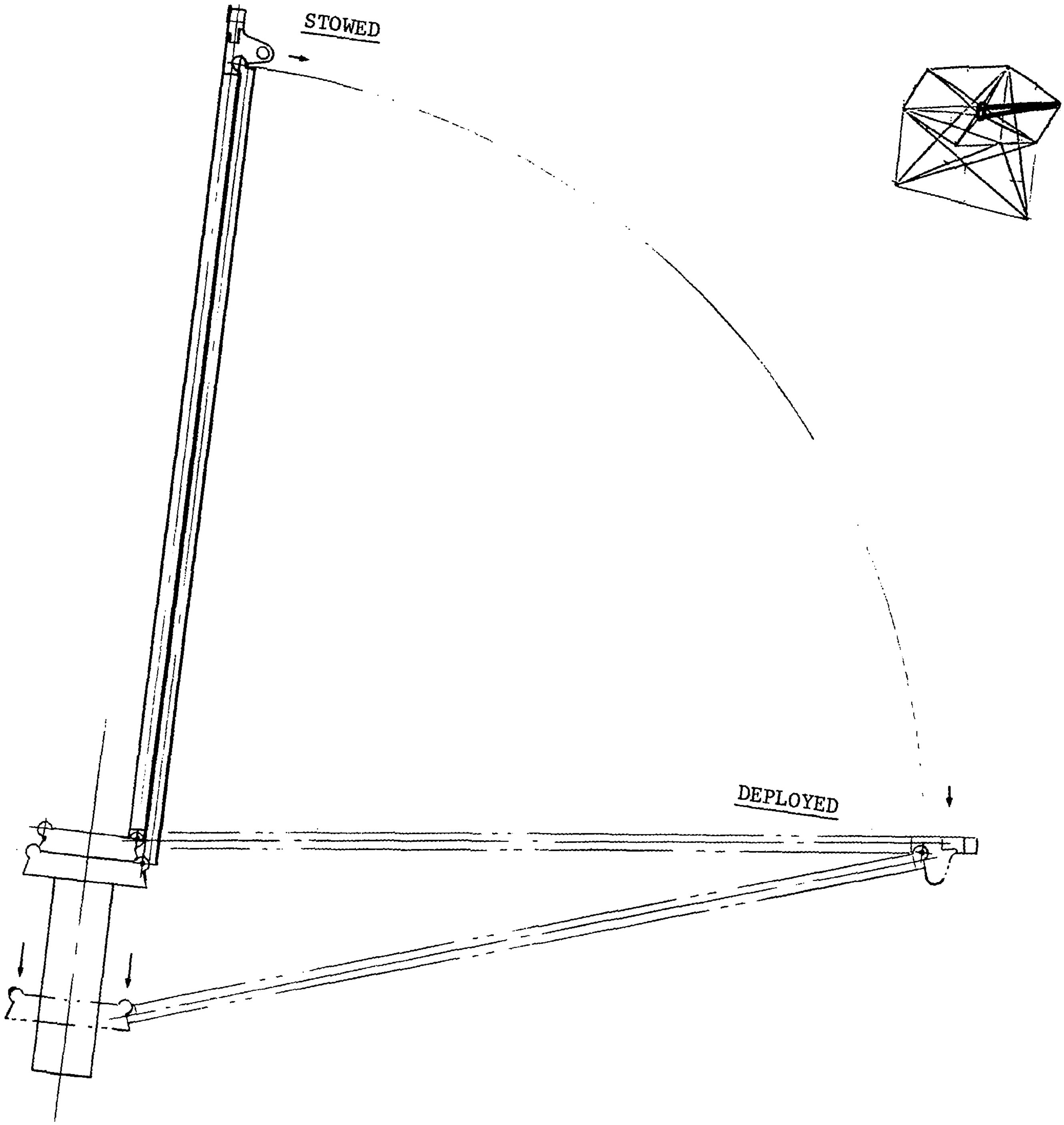


Figure 4. Front Surface Linkage Kinematics.

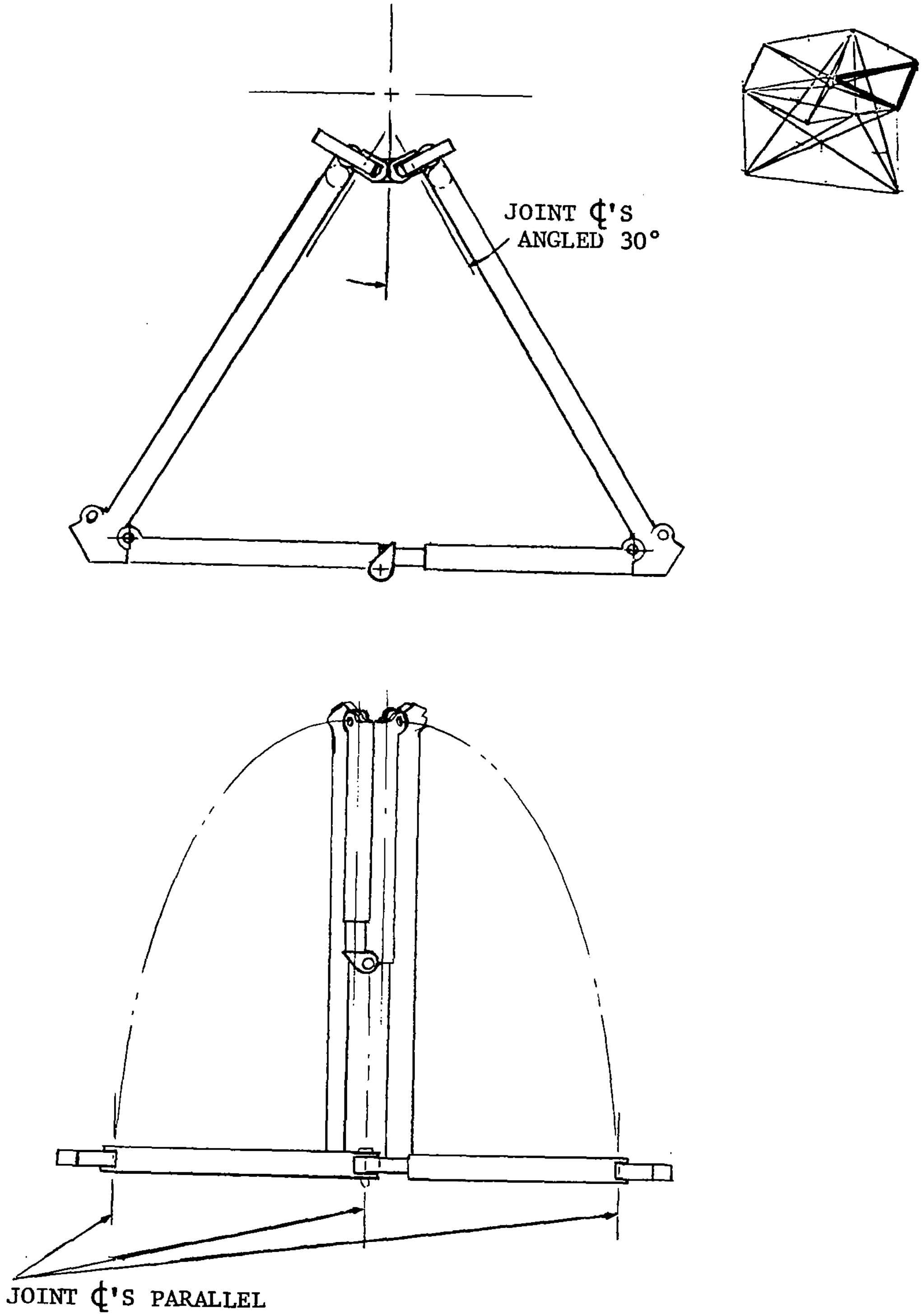


Figure 5. Perimeter Arm Deployment Kinematics.

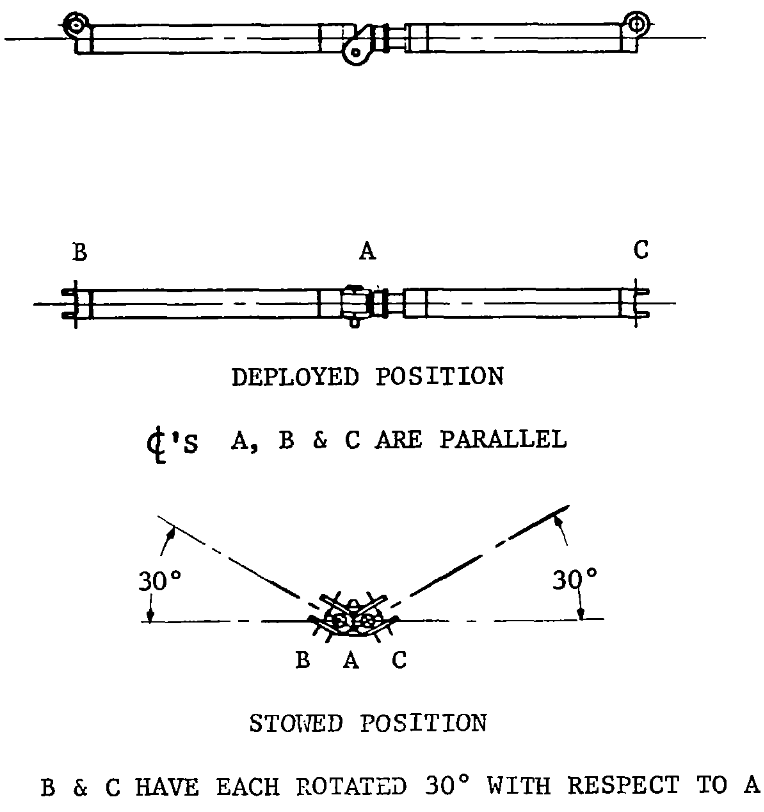


Figure 6. Perimeter Arm Mid Joint Kinematics (Torsional Rotation).

2.2.2 Lower Structure Description. Figure 7 describes the joint motions of the lower arms. The kinematic requirements can be seen to be similar to the perimeter arms, differing only in that the total rotation requirement is 120° rather than 60°.

2.2.3 Intermediate Structure Description. The remaining kinematic motions are those of the connecting cross braces between the upper surface and the lower structure. Figure 8 shows the deployment motion of one set of these cross braces. As can be seen, the motions of each brace are complex curves; they require, however, only Cardin joint motions (i.e., pivot motions about two perpendicular axes, both perpendicular to the link centerlines; similar to a common universal joint) at each end plus torsional rotation of one end of the beam with respect to the other. Two kinematic solutions to the problem are possible at the center cross joint (see Figure 9), i.e., the joint can be arranged with the central pivot axis either vertical or horizontal. With the pixot axis vertical, Figure 9A, the torsional motion required during deployment is approximately 135°, occuring at the end of deployment. If the center pivot is aligned horizontally, Figure 9B, the torsional motion requirement decreases to a maximum of approximately 45° occurring during deployment and decreasing to near zero at full deployment. However, the Cardin joint travels for this case are such that during deployment the center beam pivot must travel past its position at full deployment. Therefore, in order to use this arrangement, the travel stop which currently prevents the brace from rotating past its fully deployed position would have to be replaced by some sort of detent arrangement. This requirement would complicate the joint design unnecessarily. Therefore the configuration shown in Figure 9B was chosen for the mechanism.

2.3 Demonstration Model Description

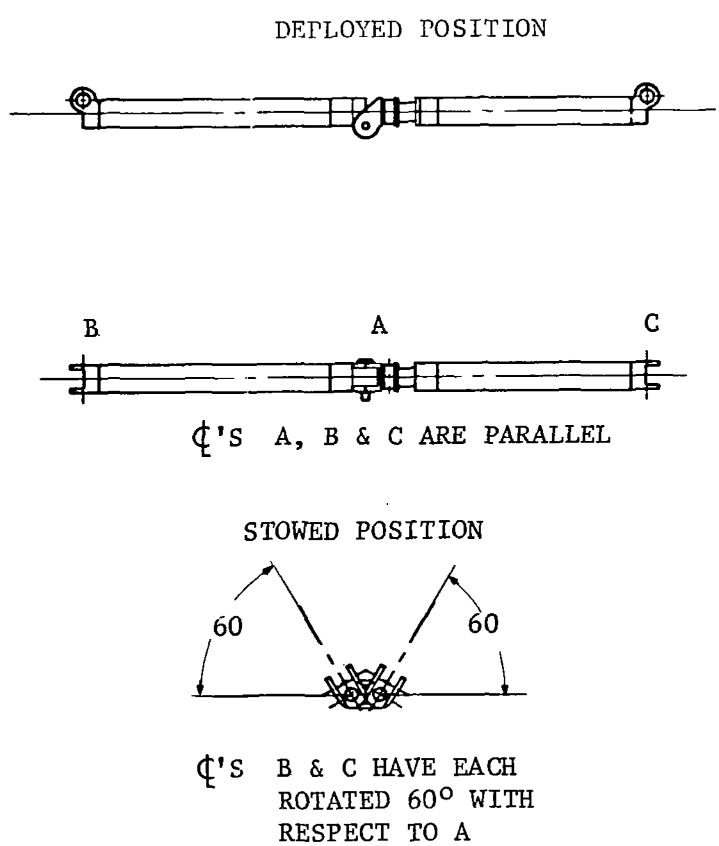


Figure 7. Lower Arm Kinematics.

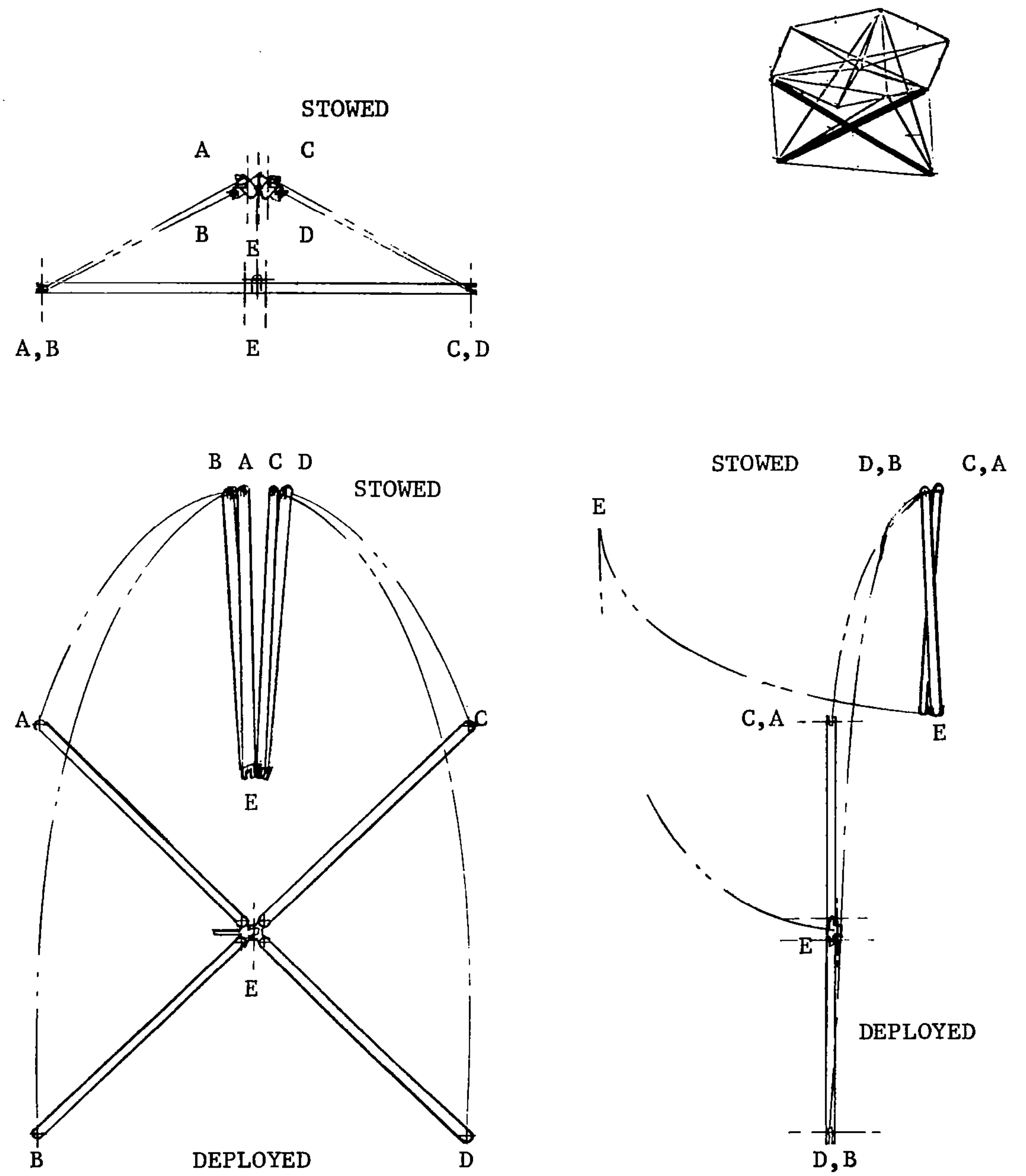
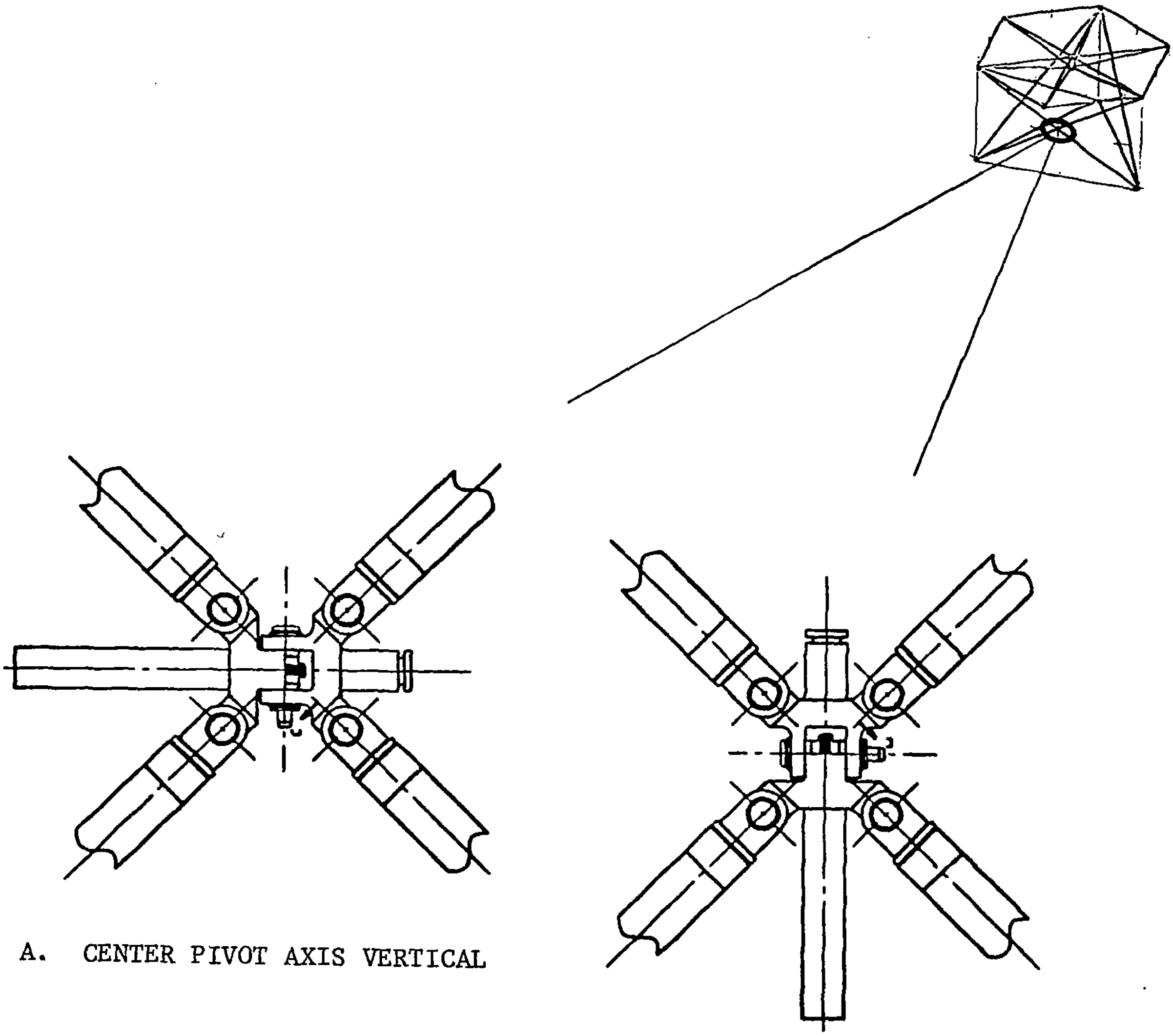


Figure 8. Cross Brace Kinematics.



A. CENTER PIVOT AXIS VERTICAL

B. CENTER PIVOT AXIS HORIZONTAL

Figure 9. Cross Brace Center Joint Configuration.

2.3.1 Requirements and General Arrangement. The foregoing kinematic study and module tube sizing (Sections 2.2 and 2.1) established a number of design requirements for a demonstration model of the deployable module. Table I gives the full list of design requirements for the assembly. Figure 10 shows the model in its stowed position, Figure 11 shows it fully deployed, and Figure 12 lists pertinent features and overall dimensions of the structural members. The 1.57 m (62 in.) dimension across the corners of the hexagonal surface is chosen to make the overall height of the stowed module/deployment stand assembly approximately 2.25 meters, allowing the model to operate satisfactorily in a room with an 2.4 m (8 ft.) ceiling. The material selected for all the strut members is 1.27 cm (.50 in.) OD x .7 mm (.028 in.) wall fiberglass tubing per NGMA G commercial specification. This tubing is readily available in .8 m (32 in.) lengths, and therefore can be used in single lengths for all struts except the diagonal cross braces, which must be spliced.

The reflective mesh used on the model is a Dacron[1] woven mesh, identical to the mesh used on the ATS-6 reflector in 1974. The mesh is sewn to the upper radial struts with Dacron thread. The thread is routed through brass eyelets in the tubing to prevent chafing during deployment motions.

The model is deployed by an electric motor operating through reduction gearing, driving a jackscrew located at the center of the radial arms. The motor and gearbox are housed at the top of the removable deployment/display stand (see Figure 10). This component arrangement allows one deployment motor assembly to deploy any number of reflector modules, which can then be released from the deployment motor unit and assembled into a completed structure. The display stand itself is a folding tripod, which has been modified to mount the motor/gearbox and support the model at the correct height for ground clearance at full deployment.

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[1]Dacron: Registered trademark of E. I. du Pont de Nemours & Co., Inc.

TABLE I DEMONSTRATION MODEL DESIGN REQUIREMENTS

- Model to be driven for "hands off" deployment.
- Model to be deployable in a room with an 2.4 m (8 ft.) ceiling.
- Model tube size to be 1.27 cm (.5 in.) diameter.
- Joint fittings shall be aluminum.
- Stowed package diameter shall be minimized.
- Model shall be equipped with a reflective surface material, which shall be attached to the upper structure to form a flat faceted, hexagonal surface.

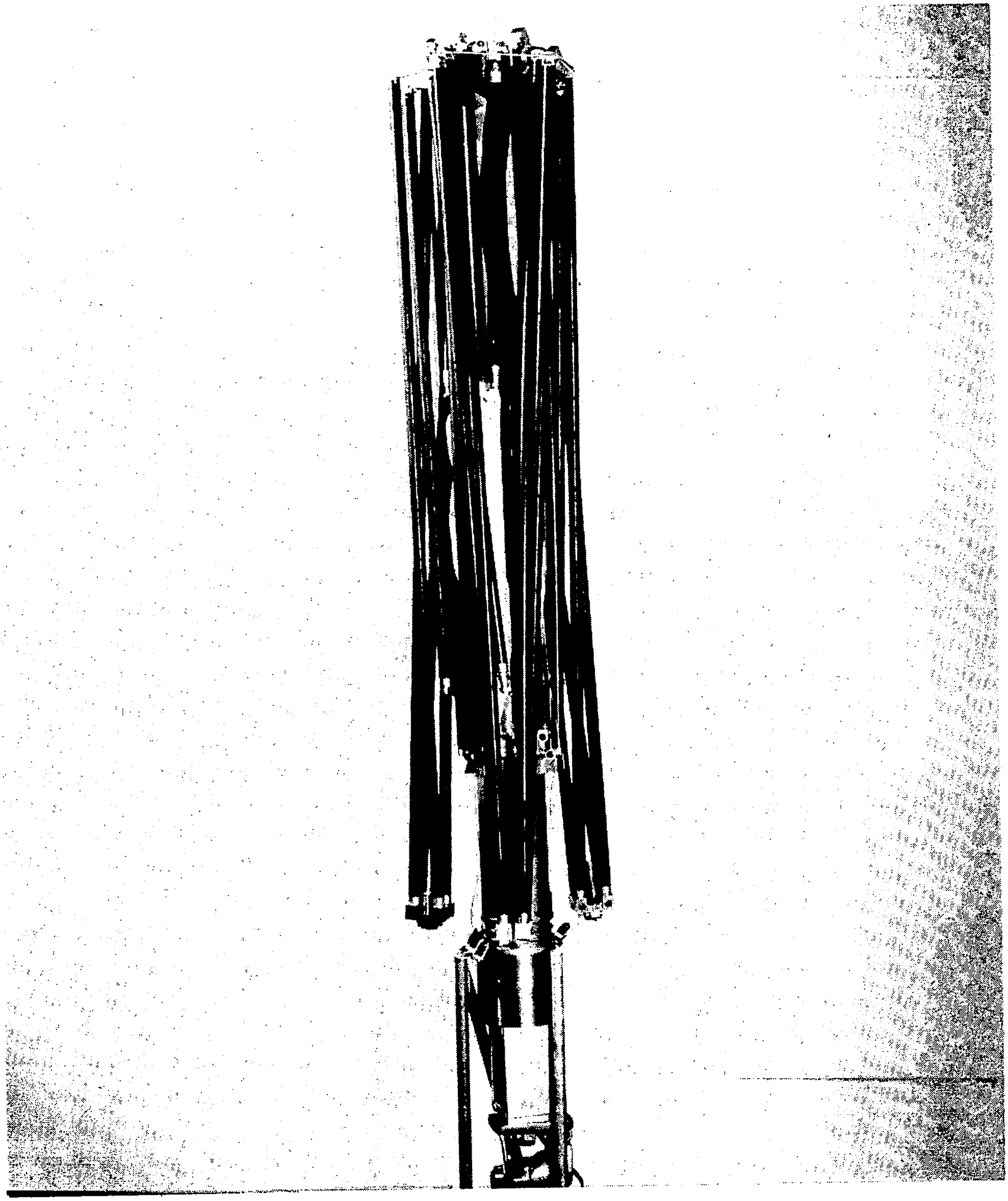


Figure 10. Demonstration Model (Stowed)

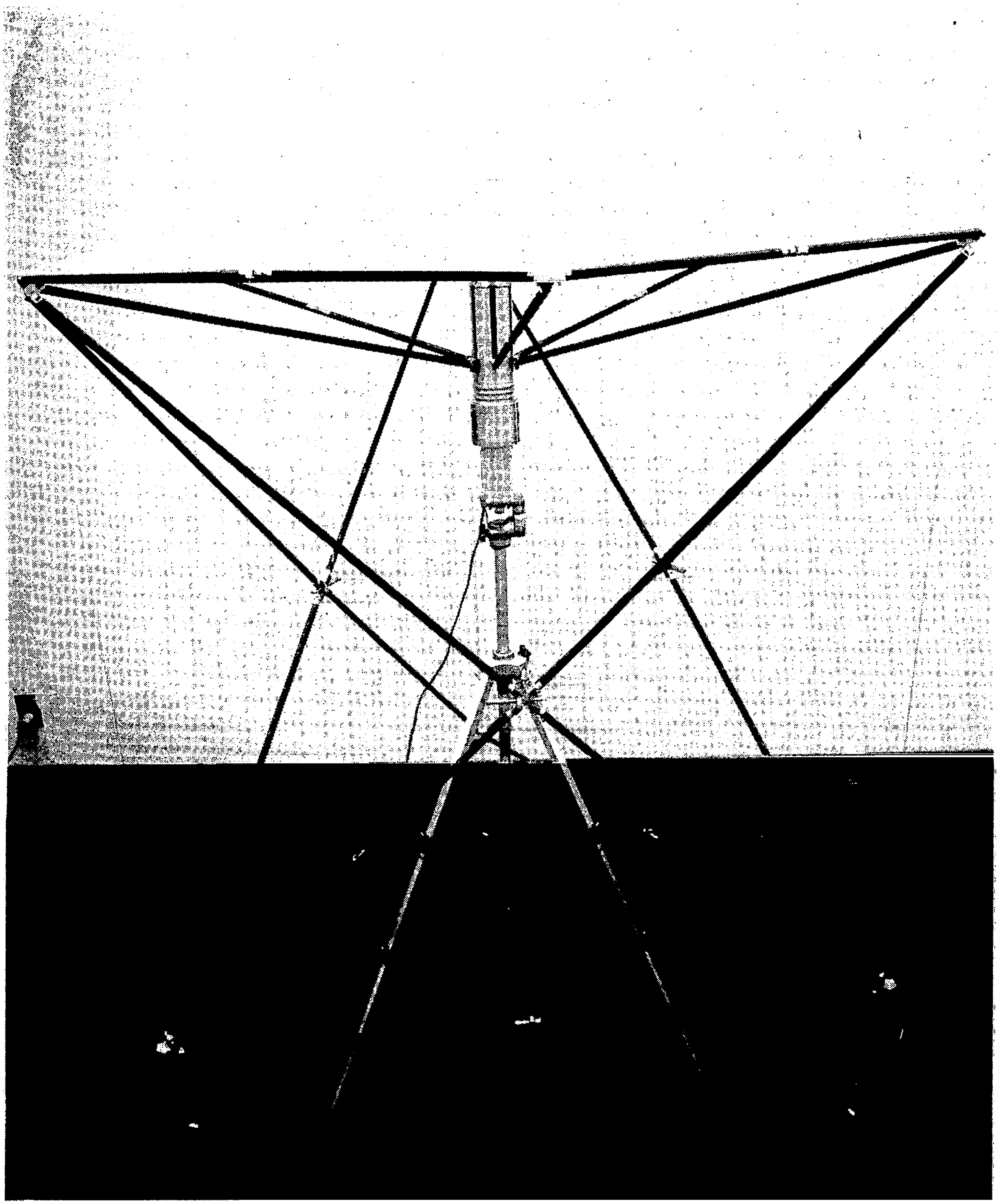


Figure 11. Demonstration Model (Deployed)

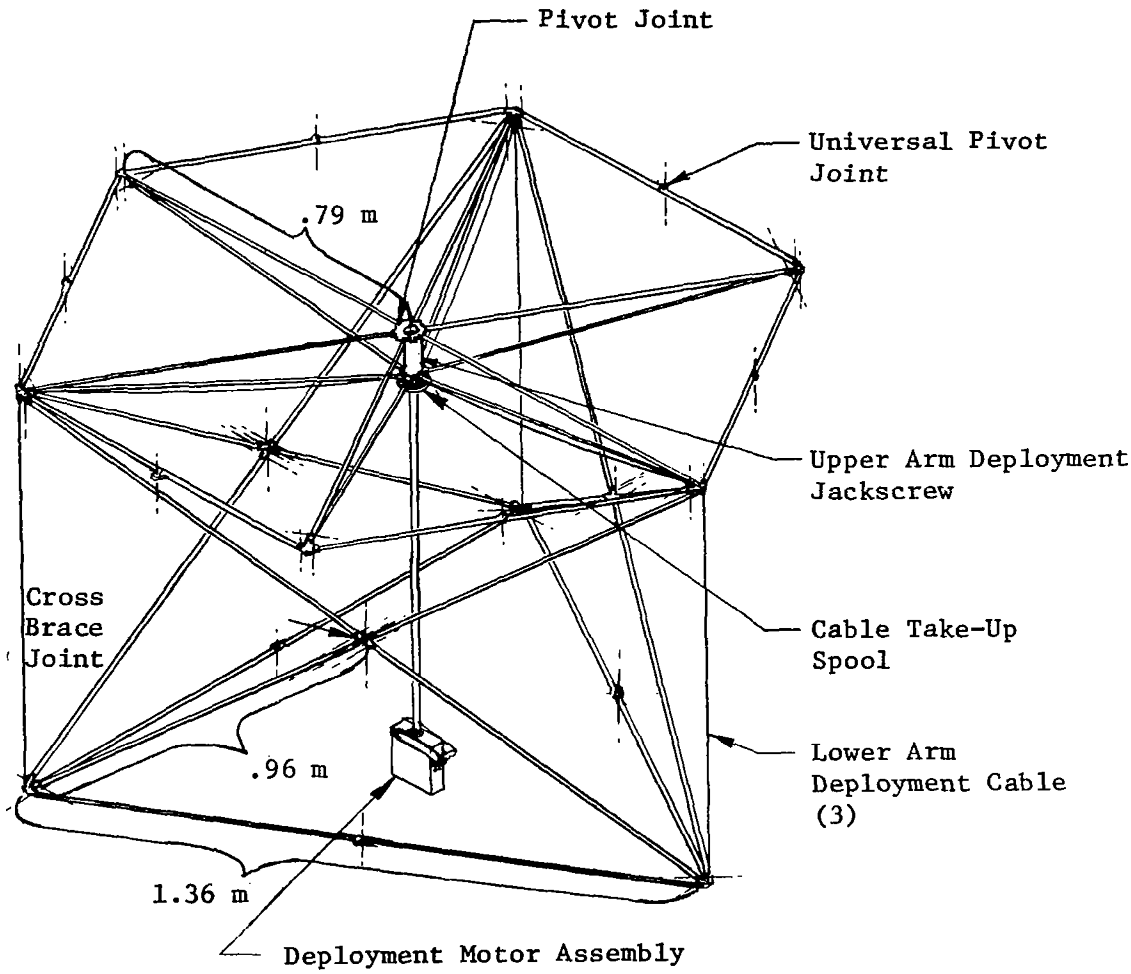


Figure 12. Demonstration Model Assembly.

2.3.2 Deployment Mechanism. Figure 13 shows a closeup of the deployment jackscrew mechanism in the stowed position, and Figure 14 shows a cross section of the mechanism. To deploy the module, the electric motor rotates the cable spool and shaft. This rotation forces the slider to move axially along the outer tube, thus moving the inboard pivots of the six lower radial arms downward. The upper radial arms are rotated outward about these inboard pivots by the lower arms.

The deployment synchronization cable spool is attached to and rotates integrally with the screw shaft. In the stowed position the spool stores the three .80 mm diameter stainless steel cables which are used to control the deployment rate of the truss braces and lower struts. As the shaft is rotated, these cables are payed out, allowing the spring loaded joints to deploy the lower structure.

2.3.3 Joint Description. The module's structural elements are connected by pivoting joints to allow for stowage. While there are a total of 54 joints in the module structure, they break down into 4 basic different types. There are 36 single axis clevis joints, of the type characterized by the inboard radial arm pivots, Figure 12. Figure 15 indicates the locations of these joints, and Figures 16 through 18 are photographs of the individual joint installations in the model.

The second basic joint type is a latching pivot joint plus torsional rotation joint (Figure 19). These joints are required in the model to accommodate the kinematic motions at the perimeter arm and lower arm mid-span fold joints. The link lengths in the demonstration model, approximately .4 m for the perimeter arms and approximately .7 m for the lower struts, will not accommodate the 30° or 60° torsion movement required during deployment without structural failure, so this joint includes a torsional bushing on either side of the pivot joint. The joint also incorporates a latch in the center to guarantee structural rigidity in the deployed position. Nine of these joints are used in the model,

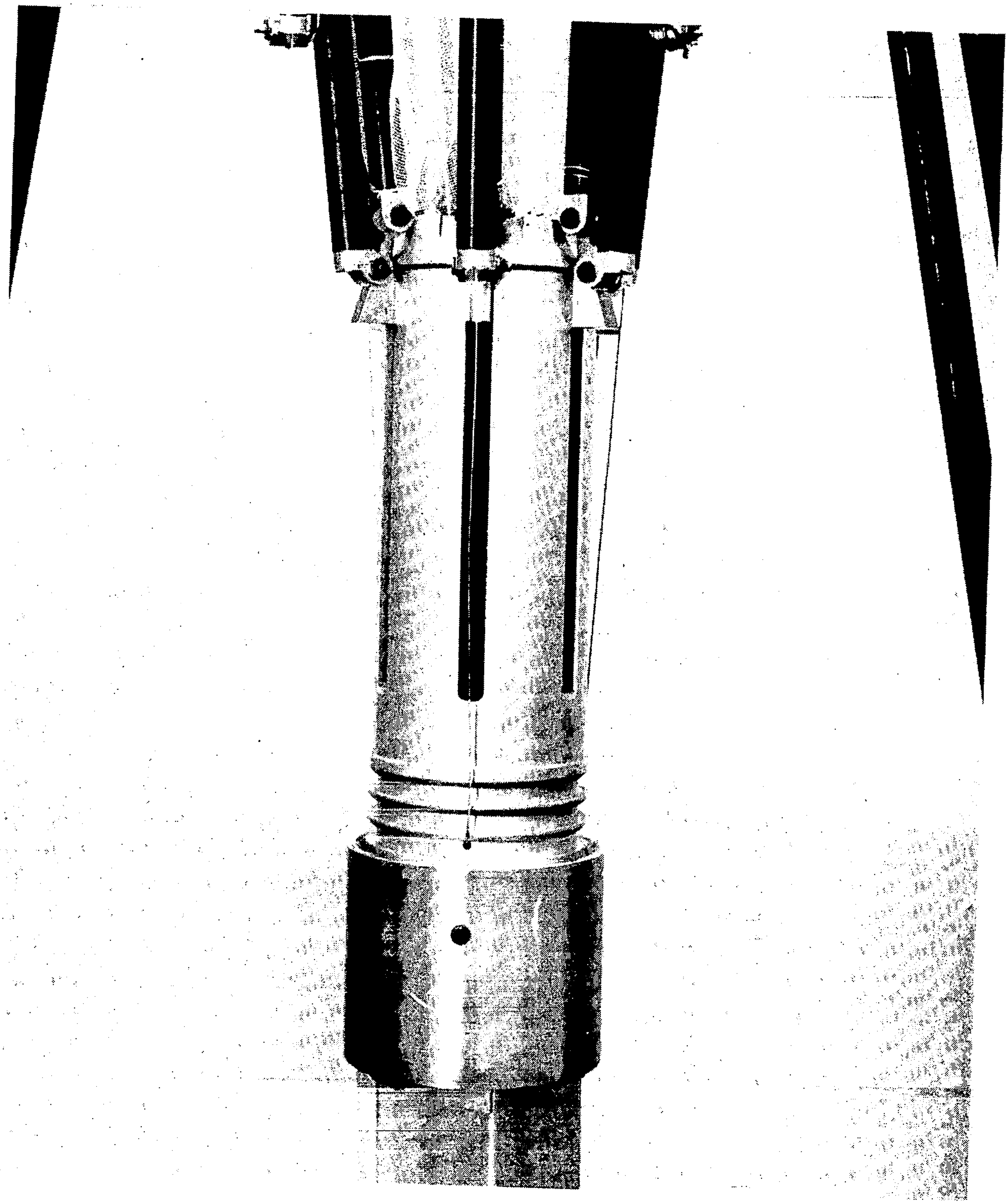


Figure 13. Jackscrew Mechanism (Stowed)

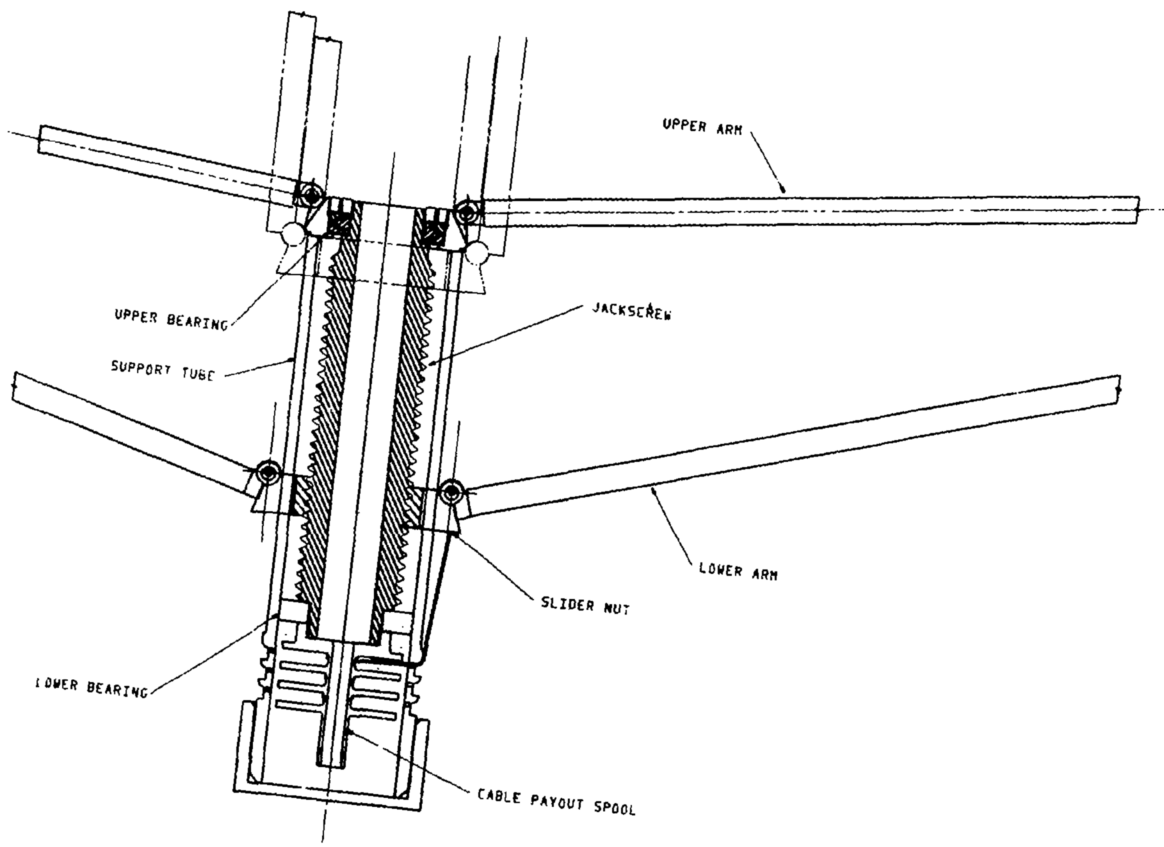


Figure 14. Jackscrew Mechanism (Cross Section).

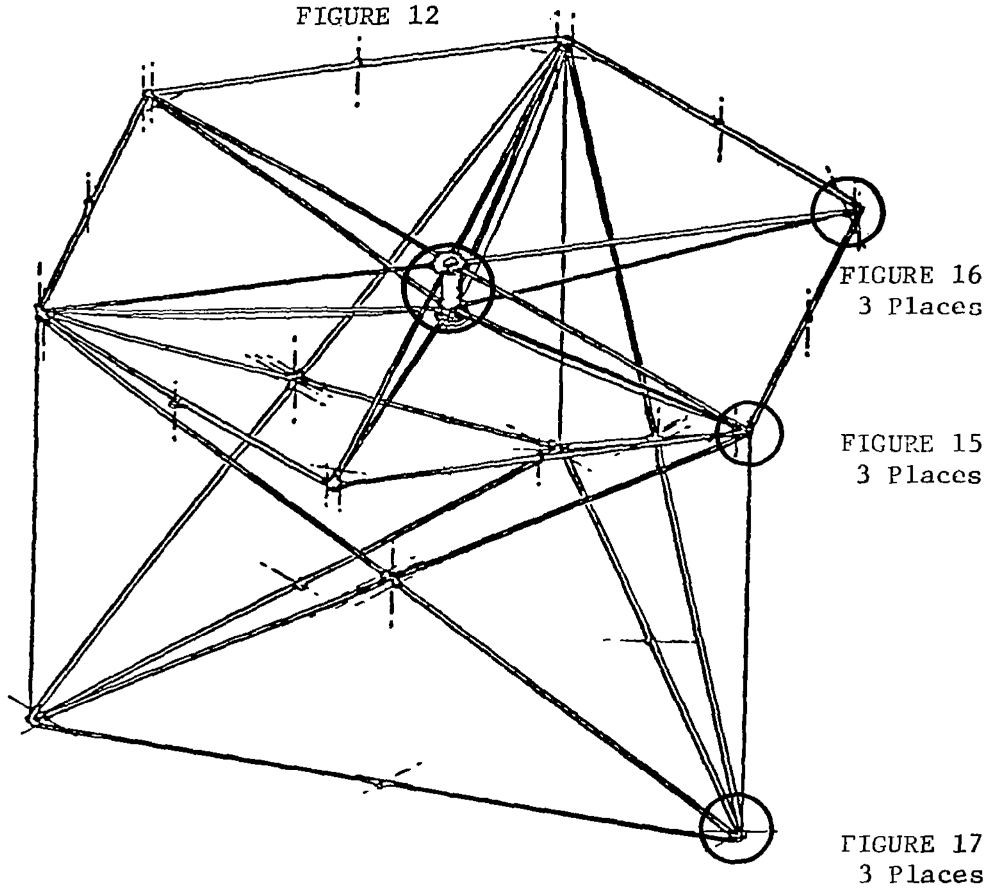


Figure 15. Pivot Joint Location Overview.

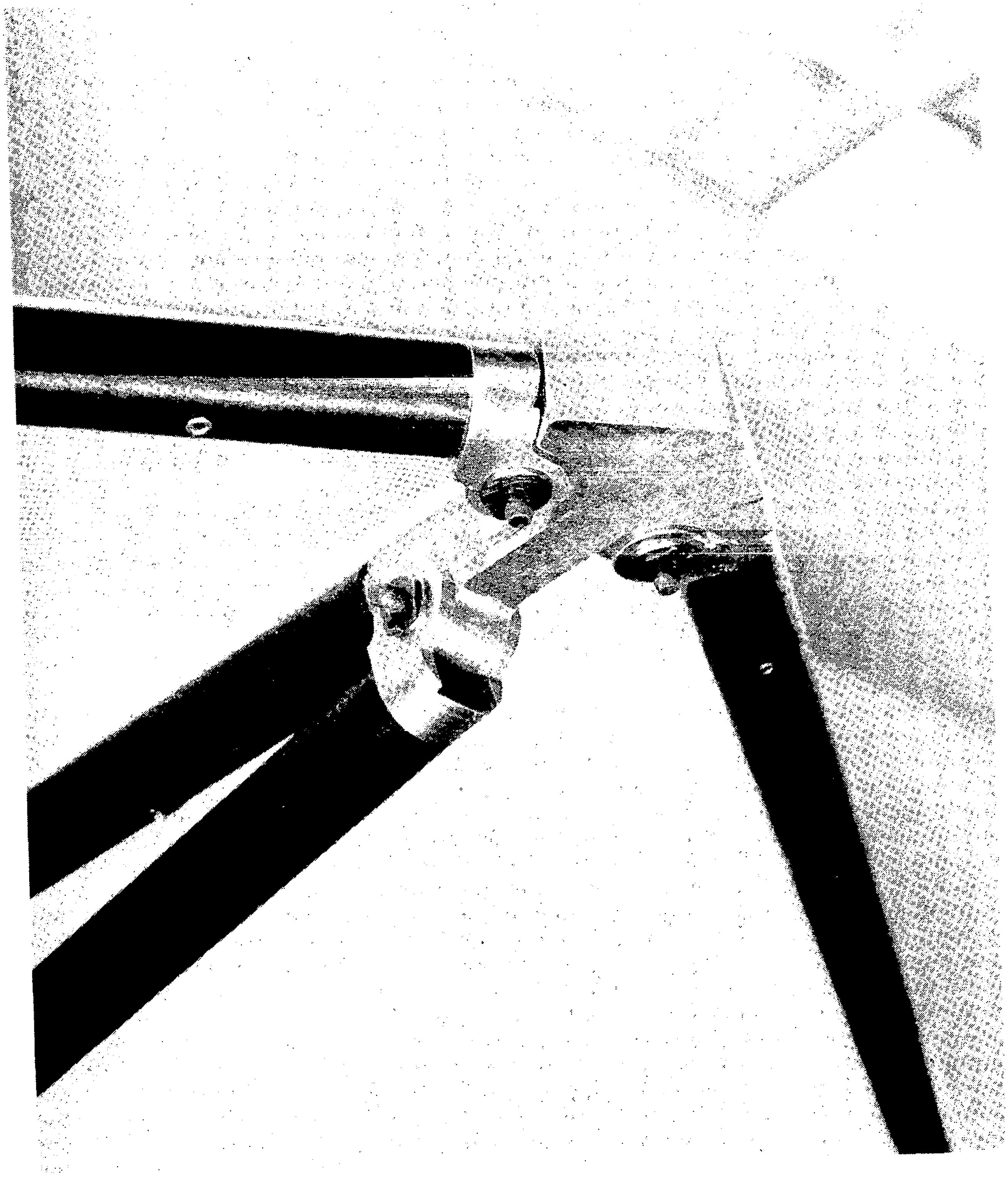


Figure 16. Perimeter Strut Pivot Joints

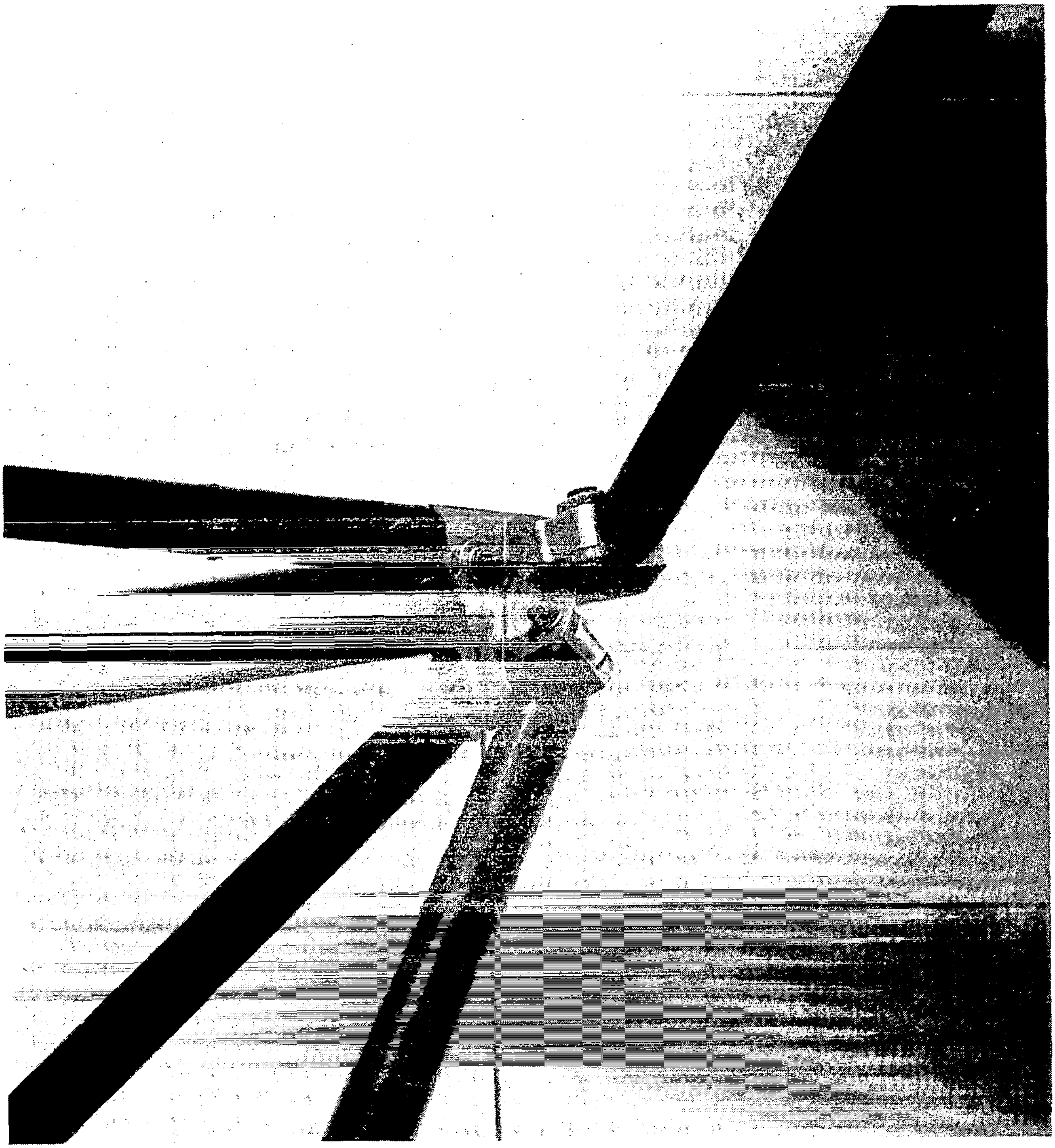


Figure 17. Perimeter Strut Pivot Joints

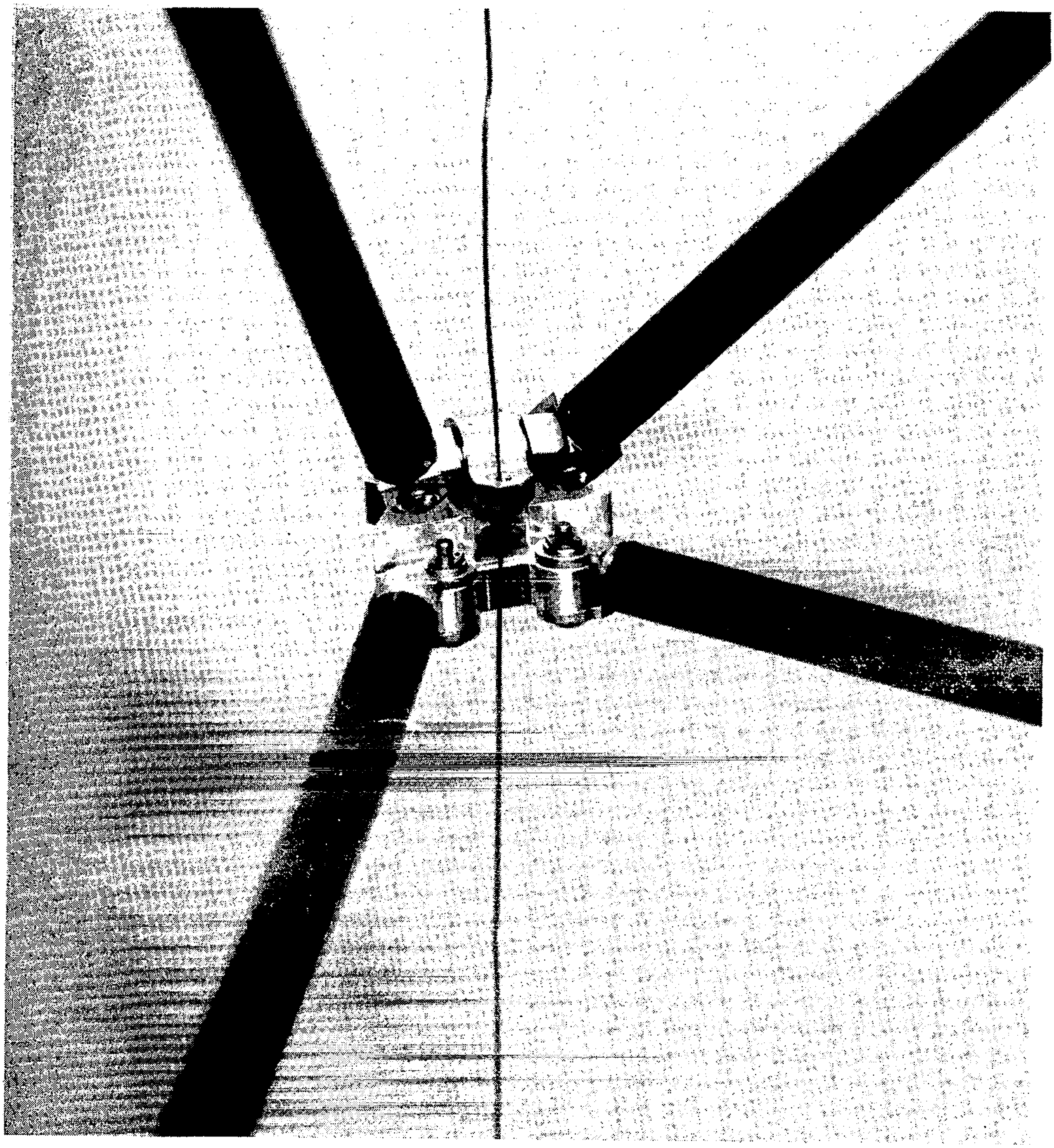
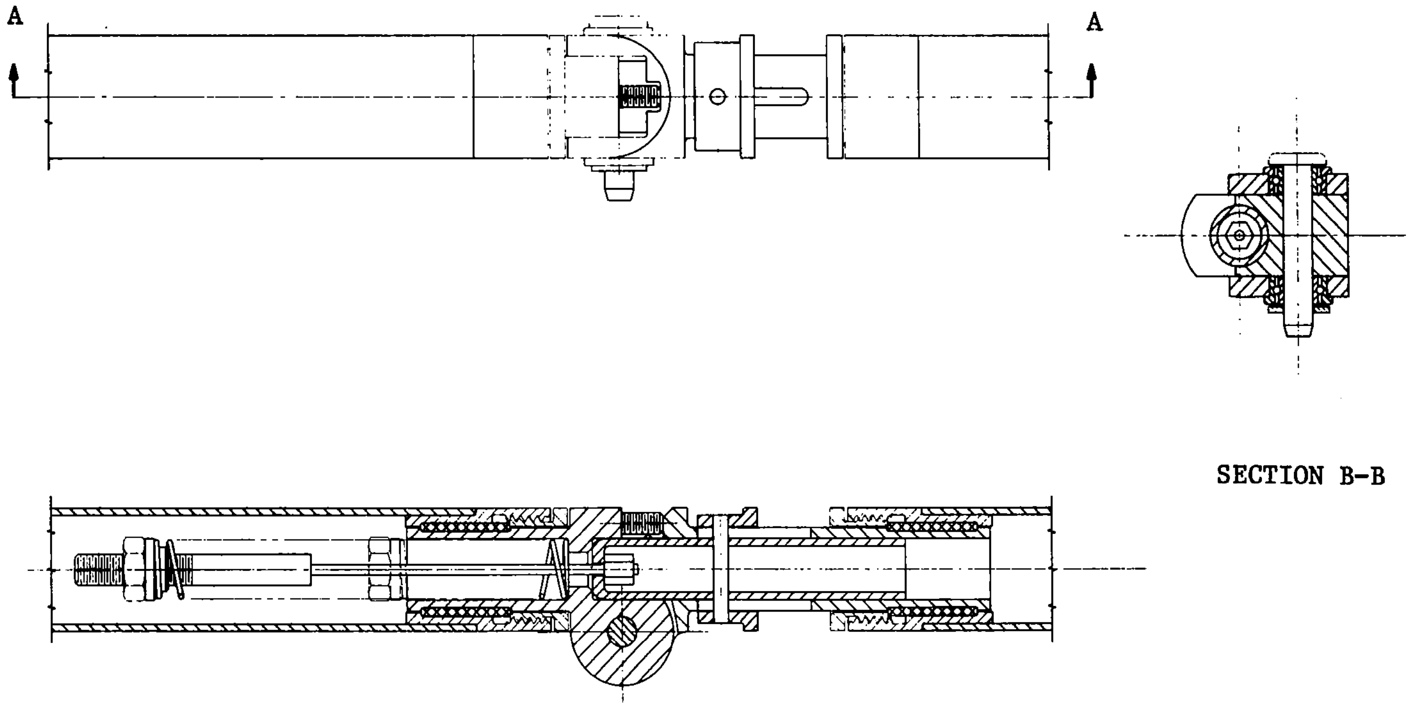


Figure 18. Lower Strut Pivot Joints



SECTION B-B

SECTION A-A

Figure 19. Pivot Plus Torsion Joint.

placed as shown in Figure 20. Figures 21 and 22 are photographs of one of the perimeter arm joints in the stowed and deployed positions.

The deployment motions of the upper and lower ends of the cross braces are accommodated by the third basic joint type in the model, which is a modified Cardin joint. Six of these joints are used in the model, placed as shown in Figure 23 and pictured in Figures 24 and 25. Figure 26 shows a cross section of the upper corner joint. The outboard pivot axis strut fittings are simple clevises identical to the ones used at the inboard end of the upper radial arms. The inboard pivot axis is directed perpendicular to the upper arm fittings and pivots on bearings in the upper arm fitting. This pivot arrangement allows two arm joints to share one set of mounting bearings, and also permits the motion of the inboard pivots of these joints to be slaved together by indexing the shafts of the pivots. This slaved motion forces all of the cross braces to rotate through approximately equal angles during all phases of the deployment motion.

The lower cross brace joints are identical in function to the upper joints, differing only in that, since the inboard pivot axes are further apart, an indexing spacer is inserted between the pivots to coordinate their motions, as shown in Figure 27.

The fourth joint type, shown in Figure 28, is the latching joint connecting the center ends of the cross braces. Three of these joints are used in the module, one at each of the intersections of the sets of cross brace struts.

Figures 29 through 31 are photographs of one of the completed joints in the stowed and deployed positions. This joint combines two sets of dual Cardin joints, torsion bearings in the end of each strut, and spring powered deployment and latching about the center pivot. In addition, travel stops are provided for the outer pivots to prevent travel beyond their fully deployed positions.

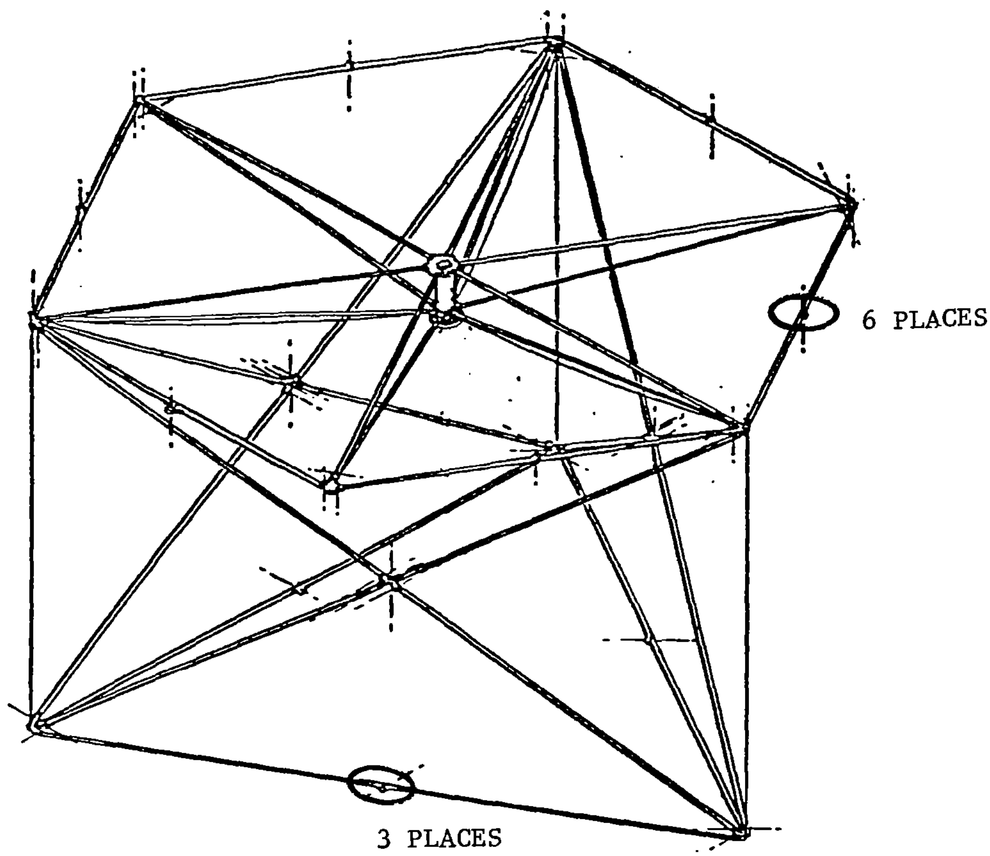


Figure 20. Torsional Pivot Joint Location Overview.

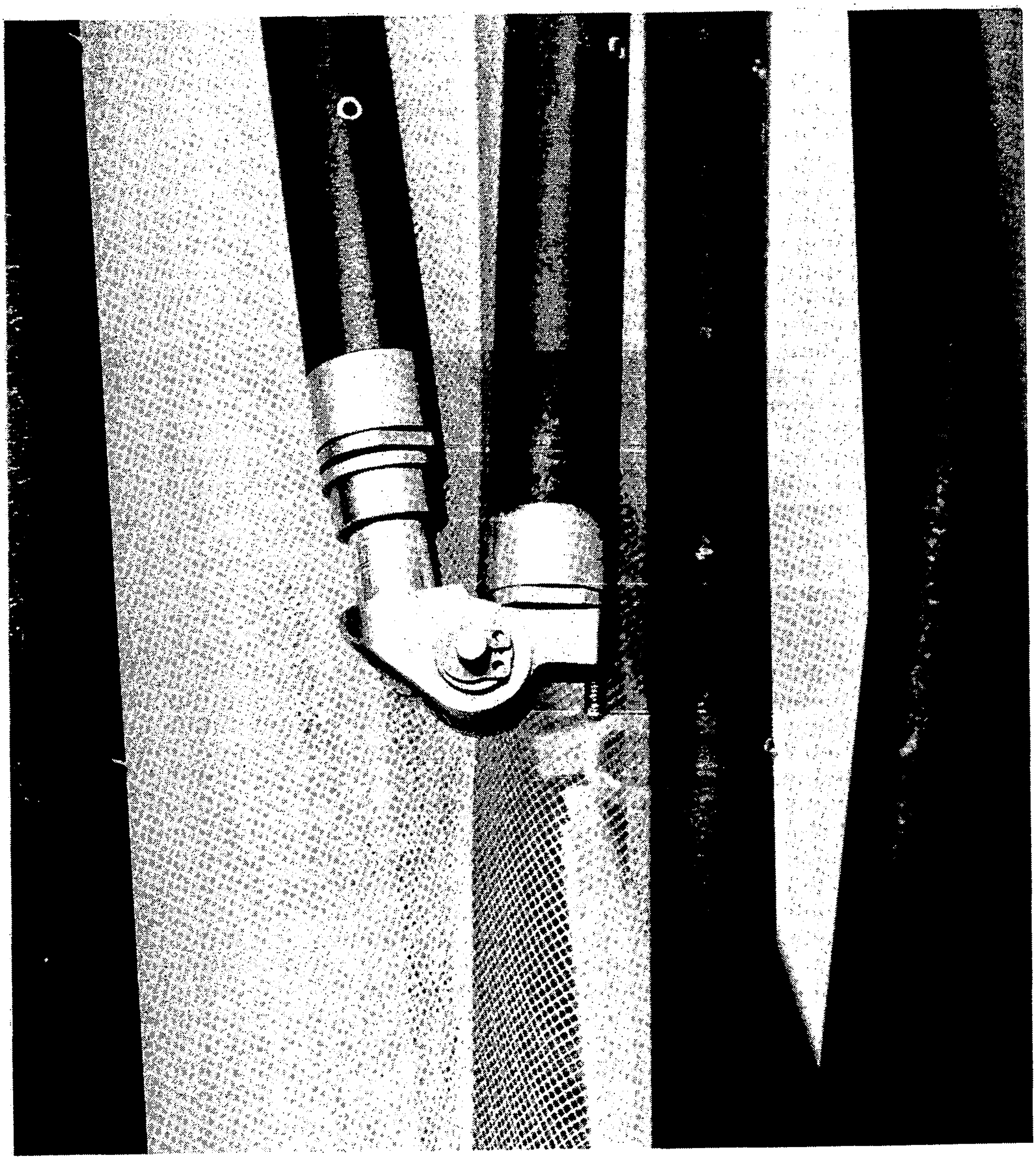


Figure 21. Perimeter Arm Mid-Span Joint (Stowed)

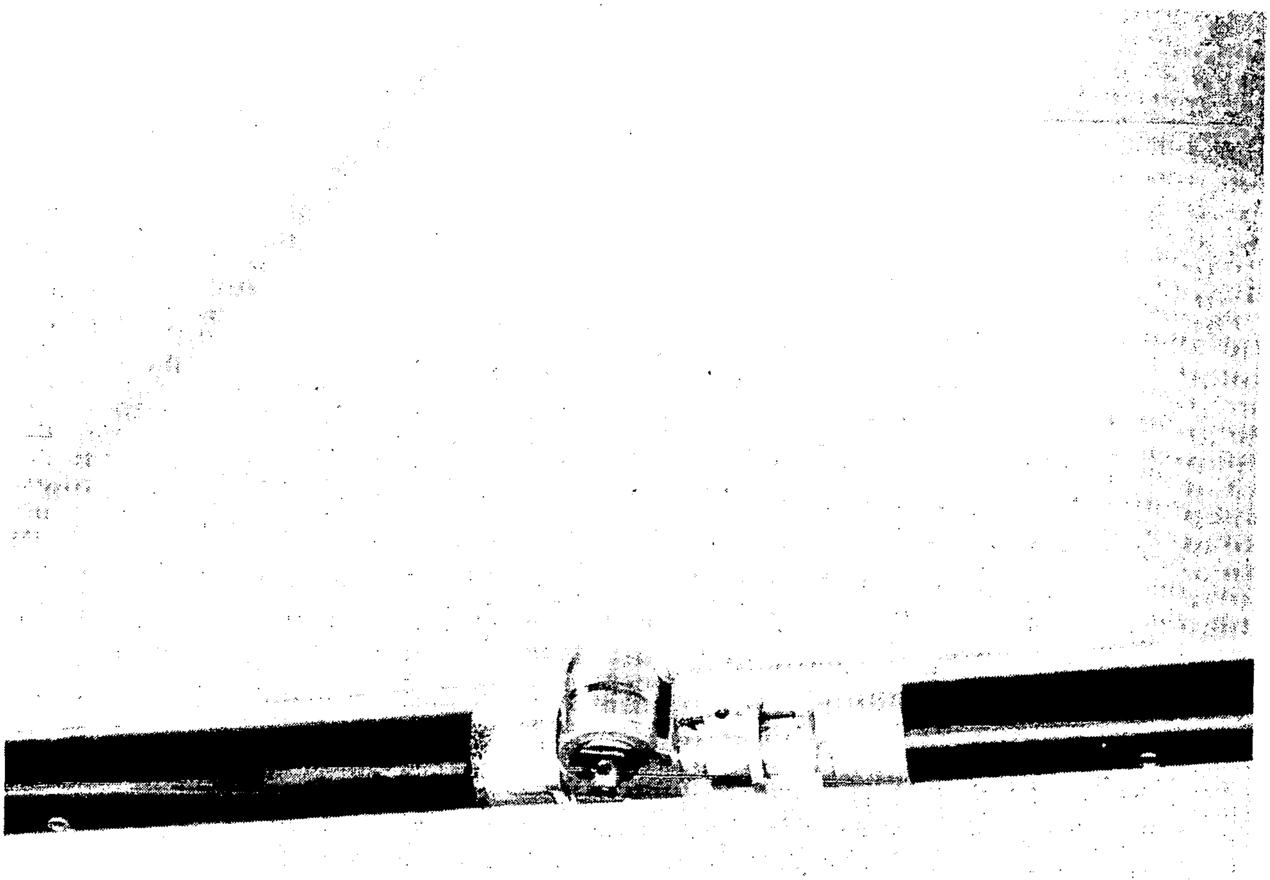


Figure 22. Perimeter Arm Mid-Span Joint (Deployed)

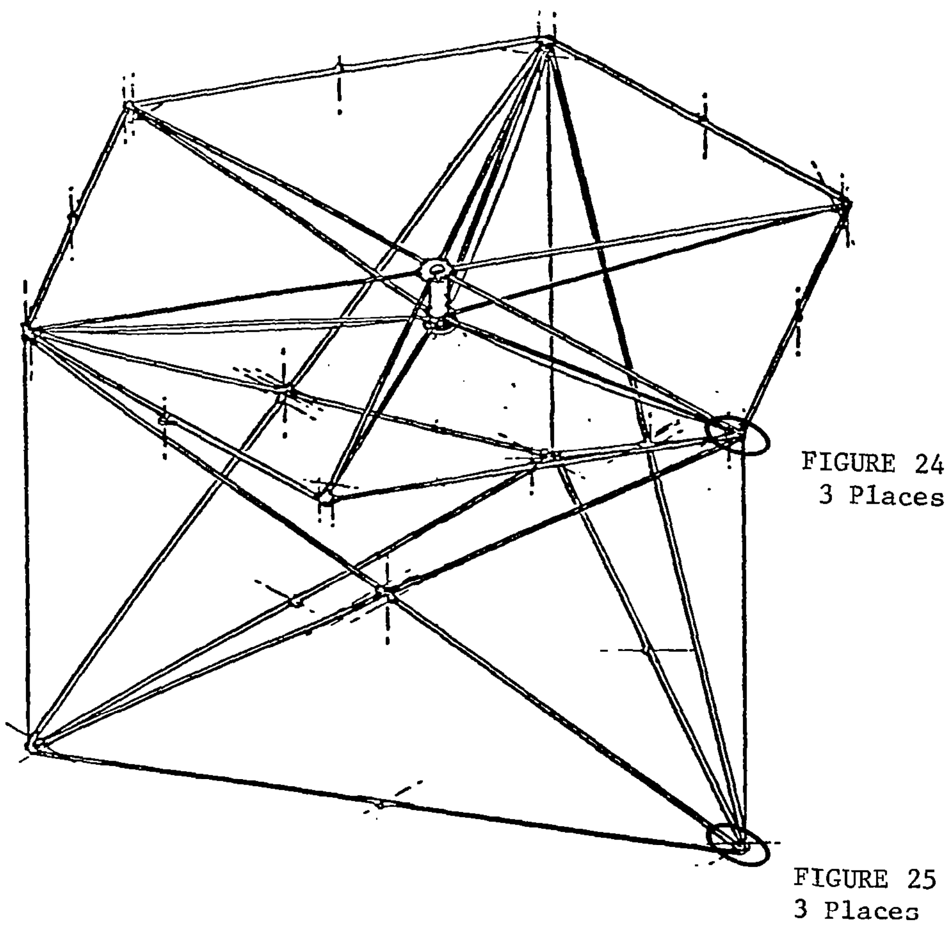


Figure 23. Cardin Joint Location Overview.

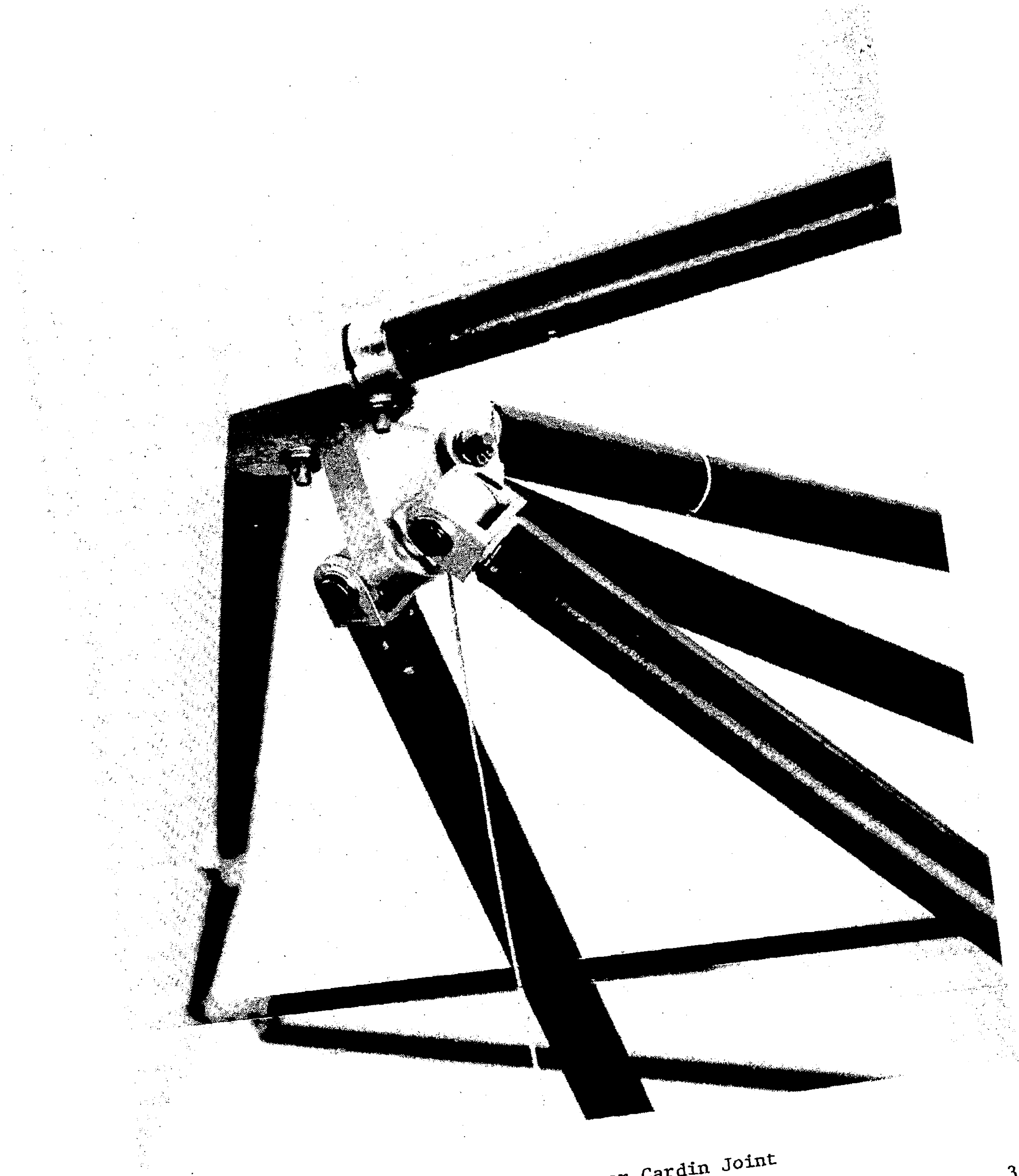


Figure 24. Upper Corner Cardin Joint

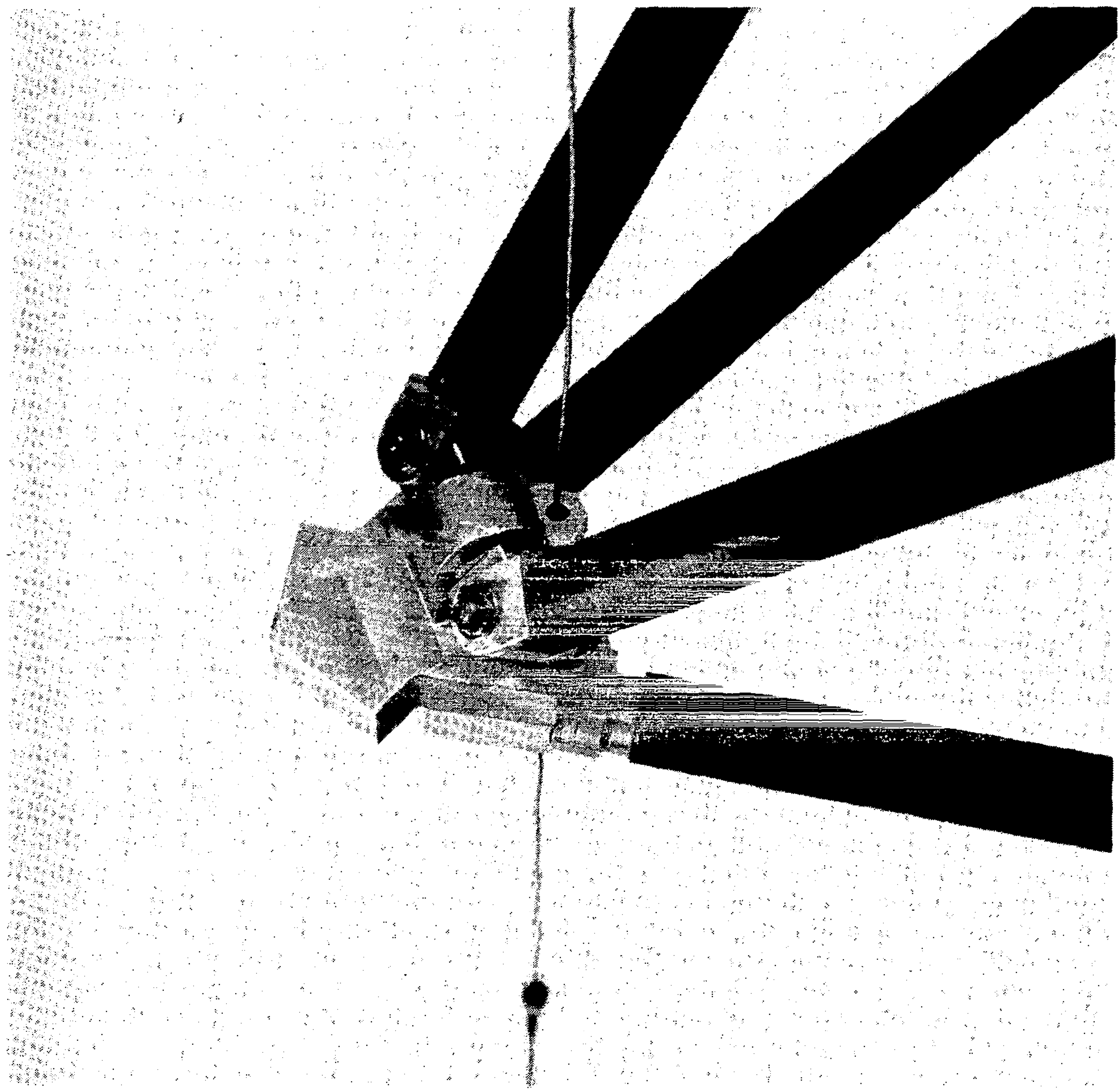


Figure 25. Lower Corner Cardin Joint

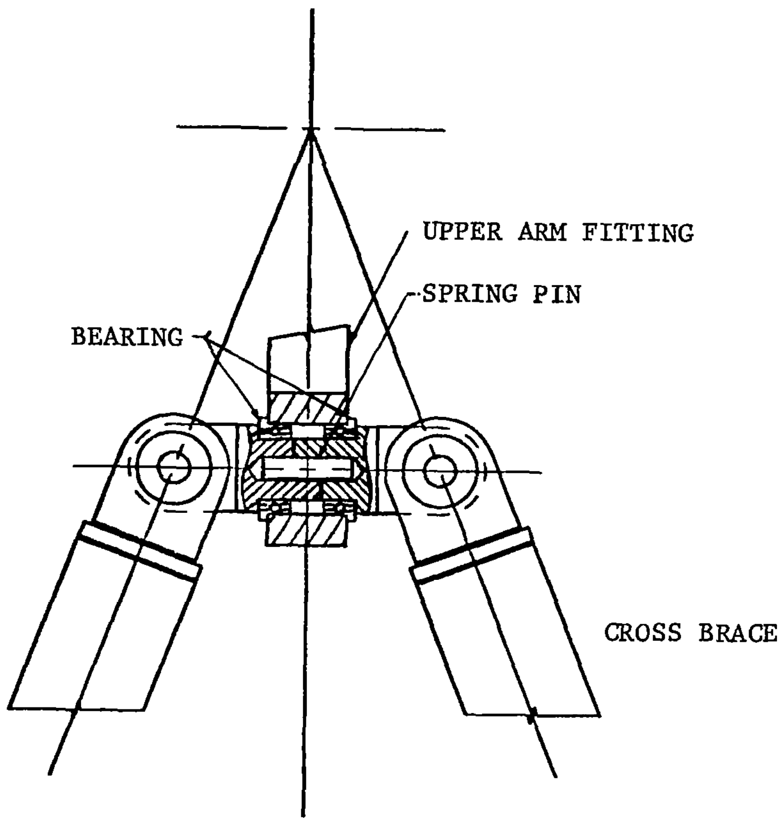


Figure 26. Cross Brace Upper Corner Joint.

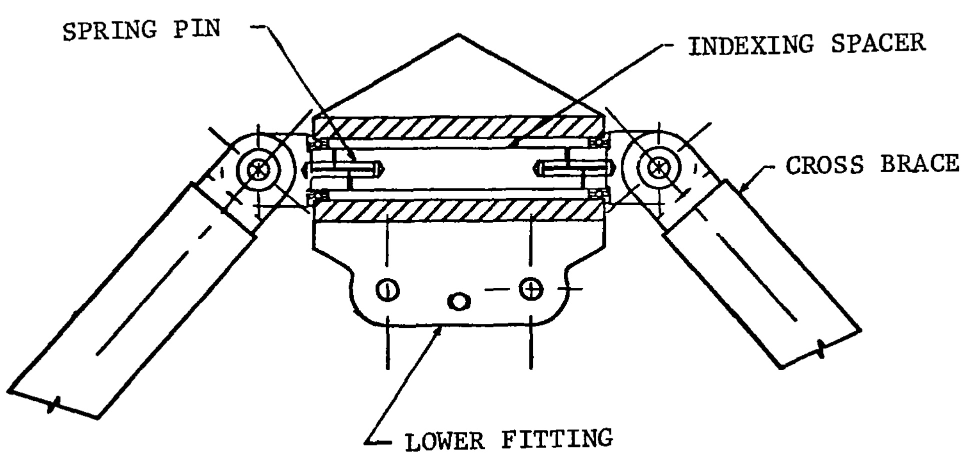


Figure 27. Cross Brace Lower Corner Joint.

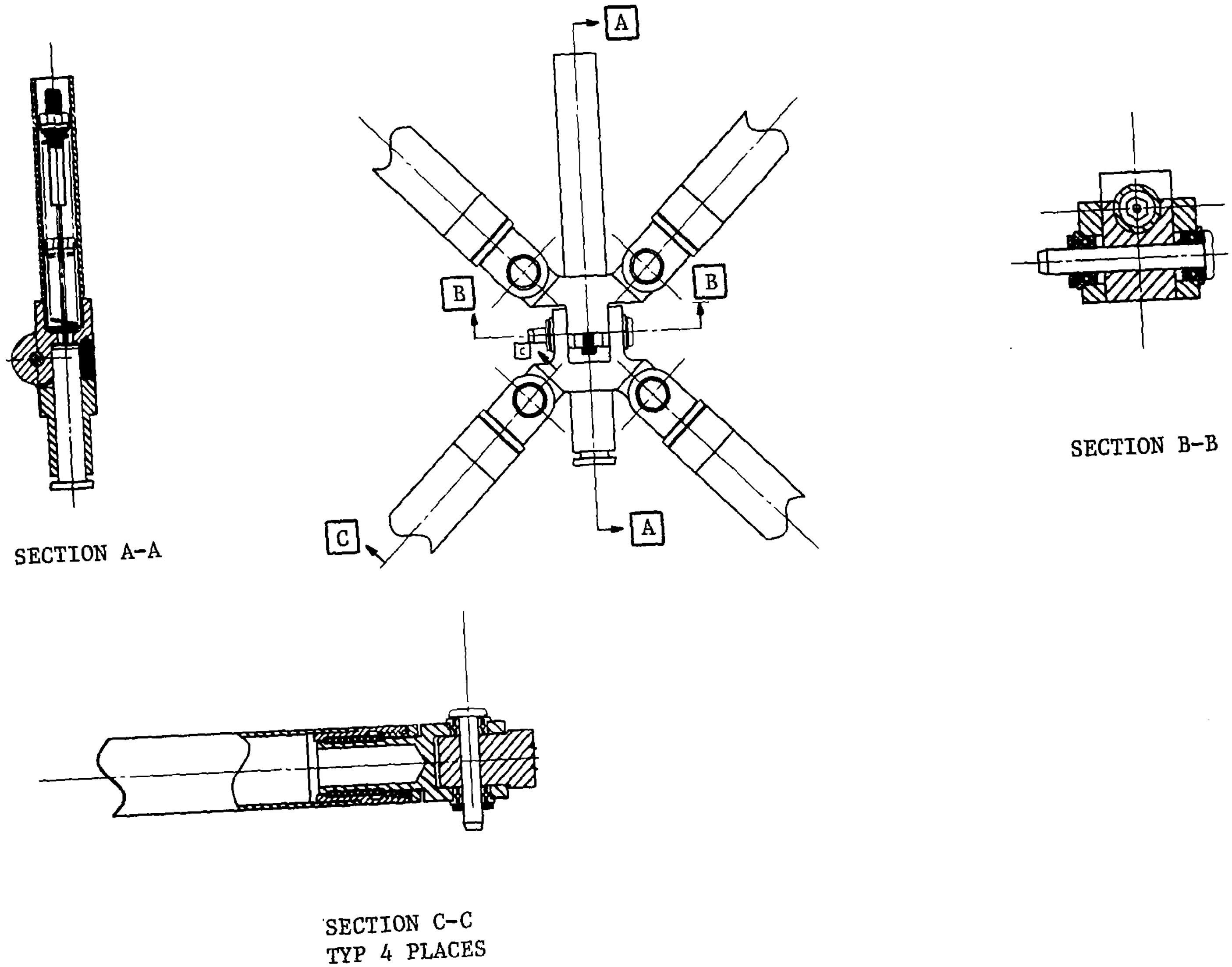


Figure 28. Cross Brace Center Joint.

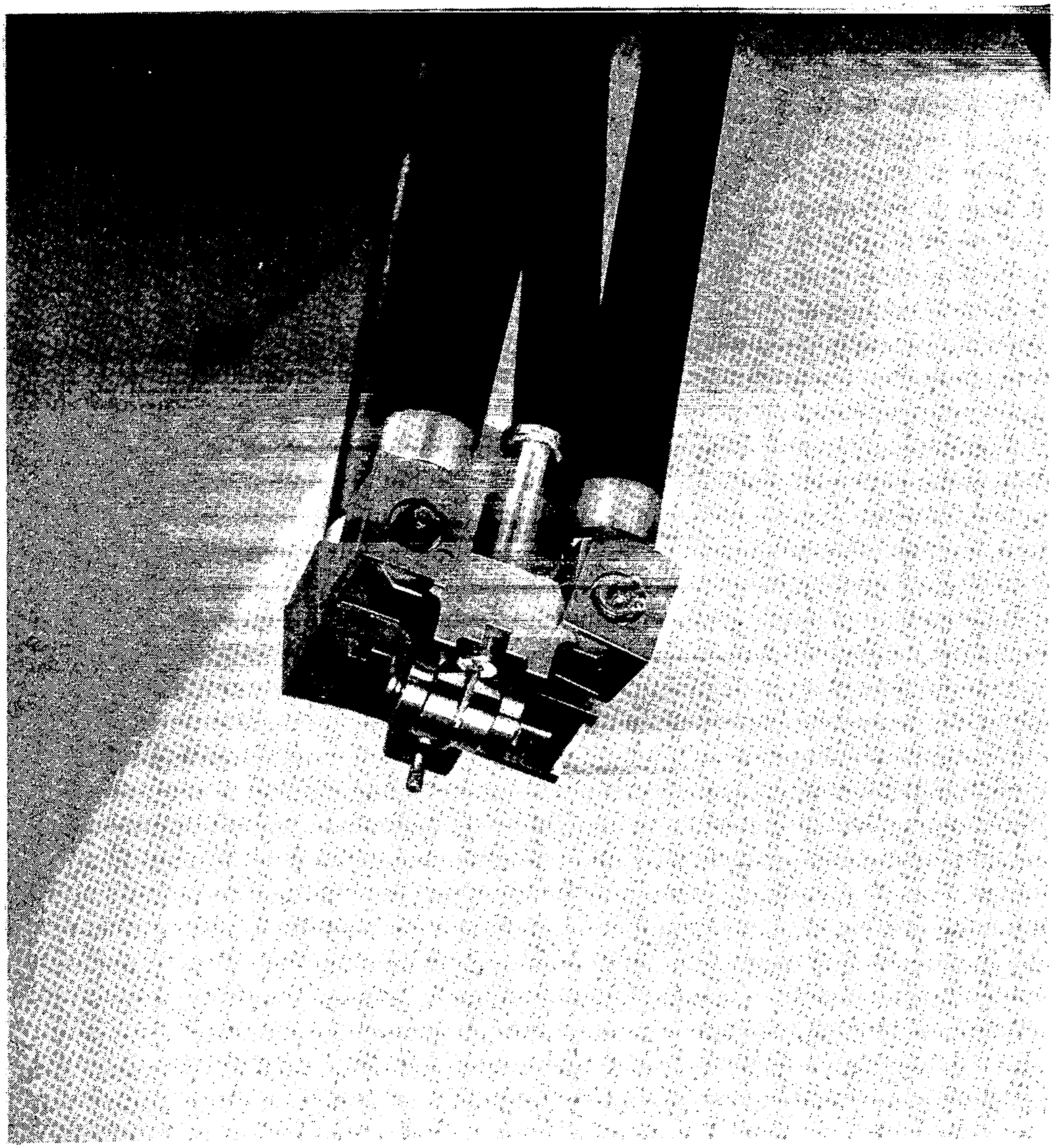


Figure 29. Cross Brace Center Joint (Stowed)

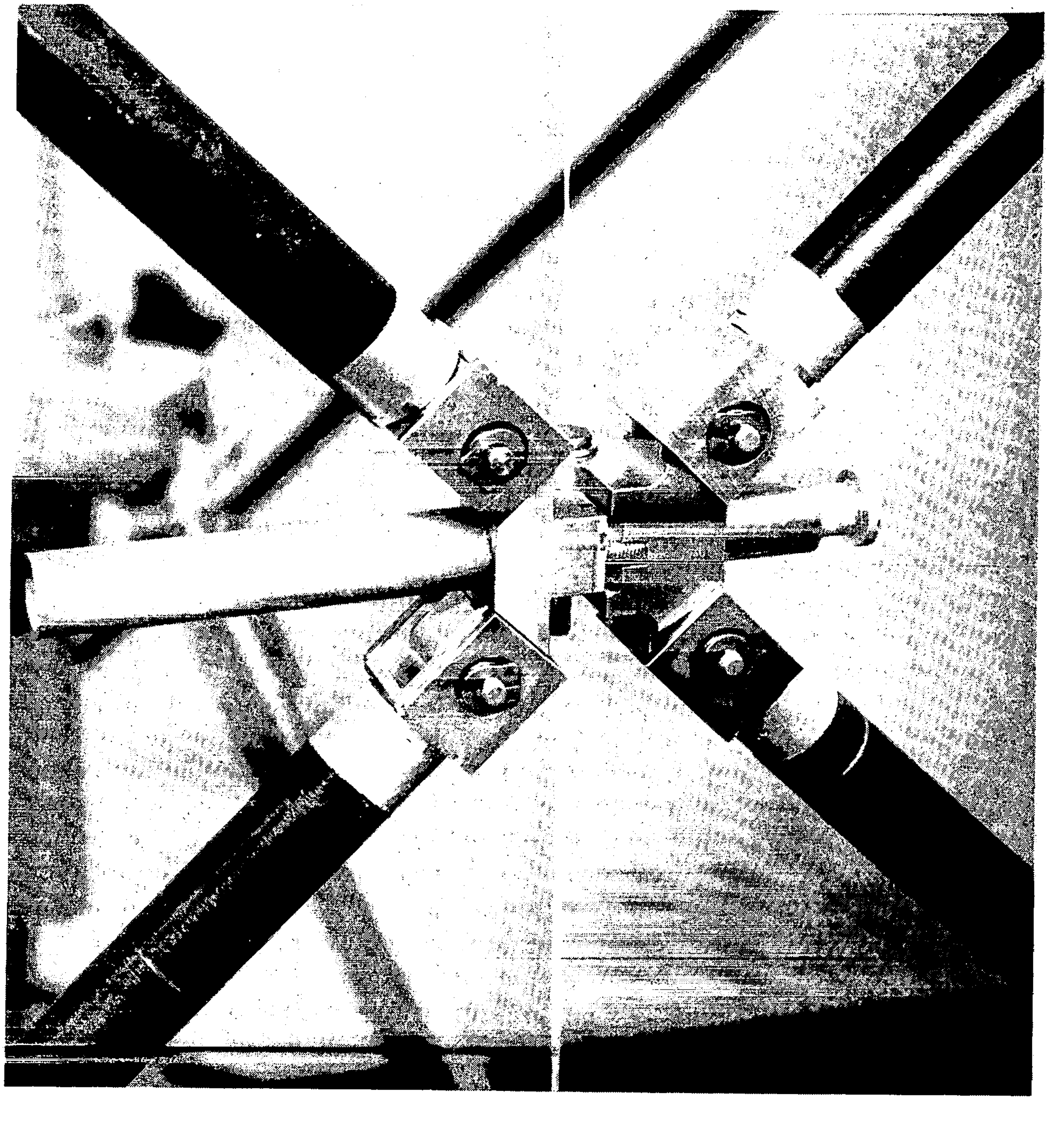


Figure 30. Cross Brace Center Joint
(Deployed - Viewed from Outside of Module)

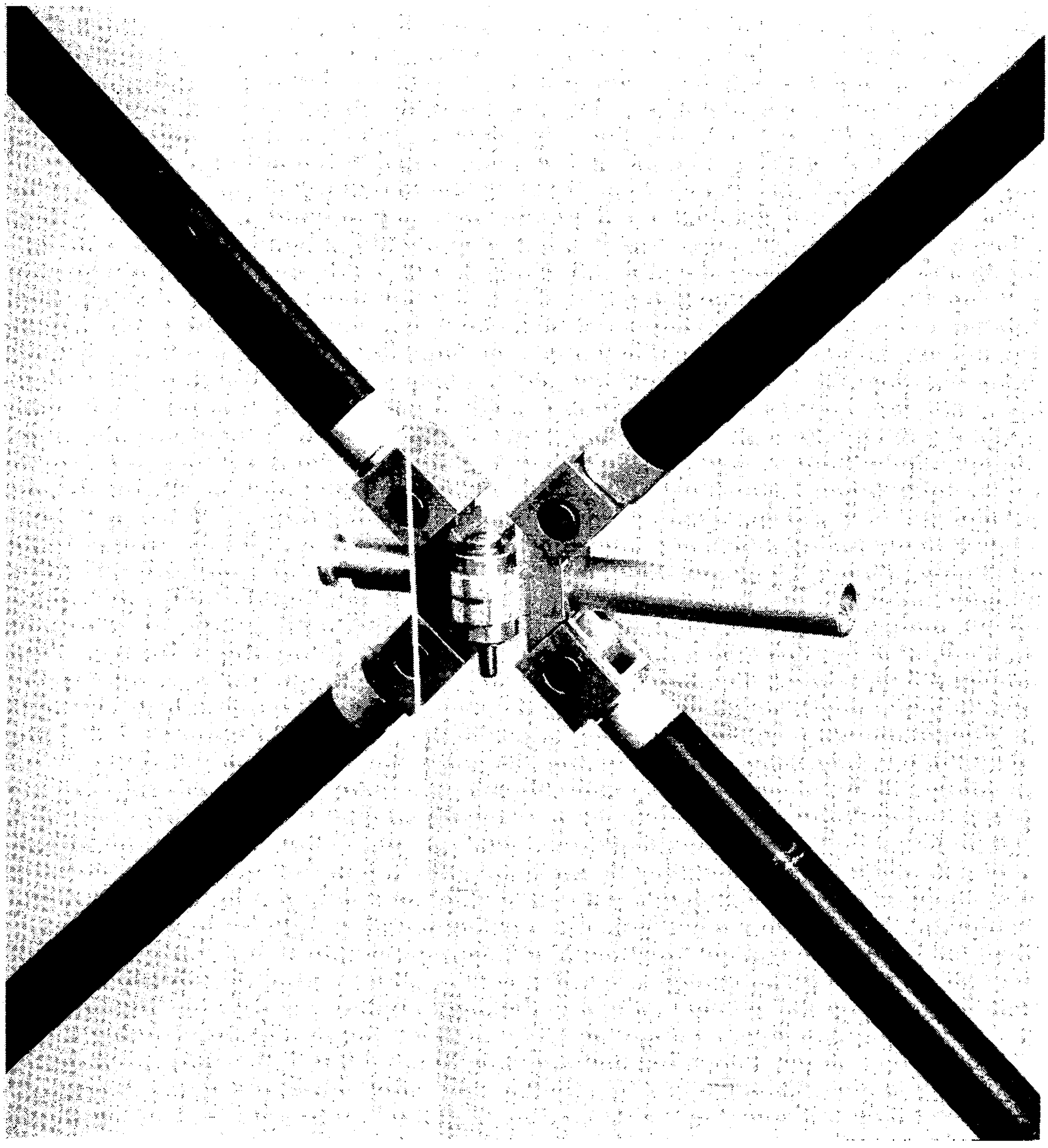


Figure 31. Cross Brace Center Joint
(Deployed - Viewed from Inside of Module)

2.3.4 Operation Sequence. The model is designed for transport and demonstration by one man. The model, its support stand, and motor control box are all transportable in one carrying case. The only requirements for the demonstration area are a 2 meter (6.5 foot) diameter area with a 2.25 meter (8 foot) high ceiling minimum and availability of standard 110 volt, 60 cycle electric power.

In operation, once the model is set up on the deployment/display stand, module deployment can be controlled from the motor control box with one pause for zero-gravity simulation. The deployment cycle can then be reinitiated and will continue to completion hands off. The motor control circuit includes, in the deploy direction, a sensing circuit which shuts off power to the motor at full deployment, should the operator be otherwise occupied.

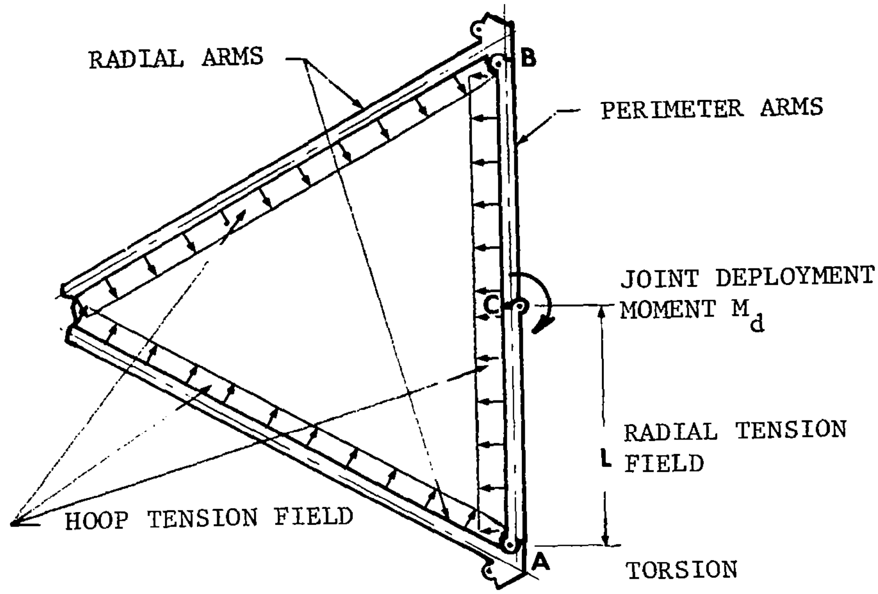
In the retract mode, two switches must be closed to operate the motor. This feature is incorporated to avoid having personnel unfamiliar with the unit attempting to retract the module without installing the hinge latch retention clips. Retraction of the module with the hinges latched will result in structural failure of the tubes, and therefore must be positively avoided.

After the unit has been completely retracted, one man can easily return the module to its shipping container.

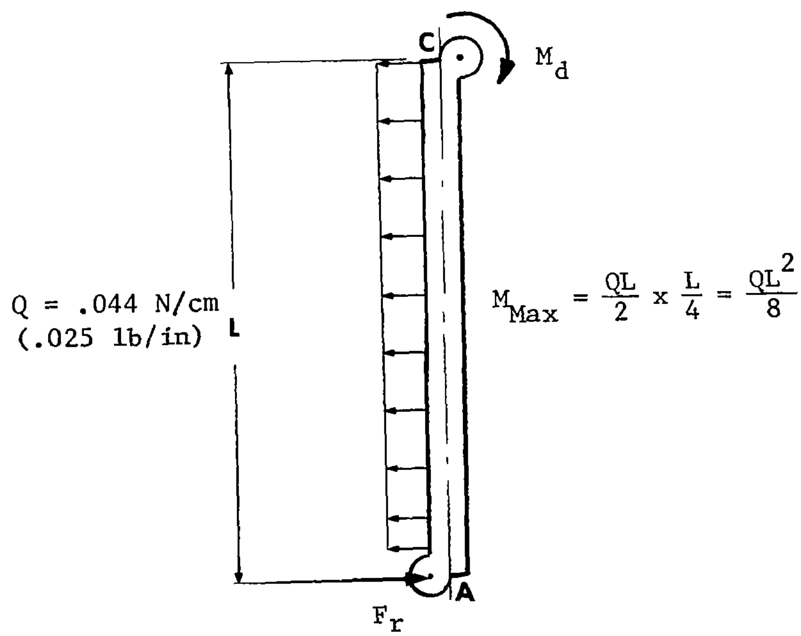
2.3.5 Demonstration Model Performance. The initial assembly and deployments of the model validated the kinematic models and identified several areas for improvement. These results and their implications on antenna module design are discussed in the following paragraphs.

Surface Considerations

The initial configuration of the model included a knitted metal mesh as the reflective surface. This mesh was sewn to the upper radial arms and perimeter arms to hold it in place. The mesh surface was prepared, and tacked to the model. Initial deployment attempts were made and the mesh was found to prevent the perimeter arms from fully deploying and latching. The difficulty was traced to the requirement, in knitted meshes, for maintaining the mesh in a biaxial tension field to eliminate edge curling, wrinkling, and to maintain the design knitted cell size. Figure 32 presents the boundary forces which must be reacted in a typical panel of the model. The particular mesh chosen required a radial tension of approximately .044 N/cm (.025 lb/in.) resulted in a deployment resisting moment about point C of approximately .5 N-m (5 in.-lb). The moment about the joint from the hinge spring at this point is approximately .24 N-m (2.1 in.-lb), coming from the 36.5 Newton (8.2 lb) force remaining in the spring at this point in the deployment motion. The arm then would require a 90 Newton (20 lb) axial load in the hinge spring, in order to insure full deployment. This spring force would be excessive when extrapolated to a full scale mode. A graphite/epoxy tube with a 1.27 cm O.D. and .7 mm wall thickness and a material bending stress allowable of 689,500 KPa (100,000 psi) has an allowable tube bending moment of approximately 16.9 N-m (150 in.-lb). With the tension field as shown in Figure 32B, this graphite epoxy tube will fail due to the tension field at a length of 5.5 meters. This would limit the modules to sizes of less than 11 meters across the corners. As a result of this concern, design solutions were identified and reviewed. The mesh radial tension load restriction can be removed by using a woven rather than knitted mesh. The woven mesh configuration derives the required shape restraint from loads only in the circumferential threads. In the interest of continuing the experimentation, the mesh on the model was changed to a woven Dacron identical to that used on the ATS-6 reflector. Since the woven mesh need only be attached to the radial arms, the adverse loading on the perimeter arms and hinges the deployment problem was eliminated.



A. MESH TENSION FIELD IN MODEL.



B. TENSION FIELD ON PERIMETER ARM.

Figure 32. Knitted Mesh Free Body Diagram.

A second solution to the knitted mesh problem can be obtained by connecting cables between the tips of each upper radial arm. The knitted mesh would then be attached to the circumferential cable as shown in Figure 33. Therefore, the mesh loads would all be reacted by the radial arms, and the perimeter arms would be free to deploy independently. This solution would, however, result in non-reflective gaps in the reflective surface of the assembled reflector due to the catenary shape of the mesh loaded cables around the perimeter of each module hexagon.

Kinematic Considerations

During assembly, an interference was noted between the upper and lower cross brace arms in the stowed position. The interference forced the lower ends of the arms radially outward and prevented them from stowing parallel to the centerline of the model. The "veeing out" of these arms is shown in Figure 34, and the arrows on the figure denote the area of interference. Experimentation with the lower corner pivot points disclosed that the problem could be eliminated by moving the lower cross brace corner pivots outward approximately 1.5 cm and downward 2.25 cm. New lower corner fittings were manufactured to relocate the pivot points, and the struts then folded in neatly along the sides of the unit, reducing the stowed diameter from approximately 36 cm to approximately 25 cm.

The model also exhibited excessive torsional free play motion in the deployed position. This motion was traced to axial and torsional manufacturing tolerances in the torsional joints. This is of little consequence for a full scale module since graphite/epoxy tubes in lengths exceeding 7.25 meters (corresponding to module sizes of approximately 12 m or larger across the corners of the hexagonal surface) can absorb the required torsional motion as elastic torsional bending in the stowed configurations. This eliminates the need for these discrete torsion joints.

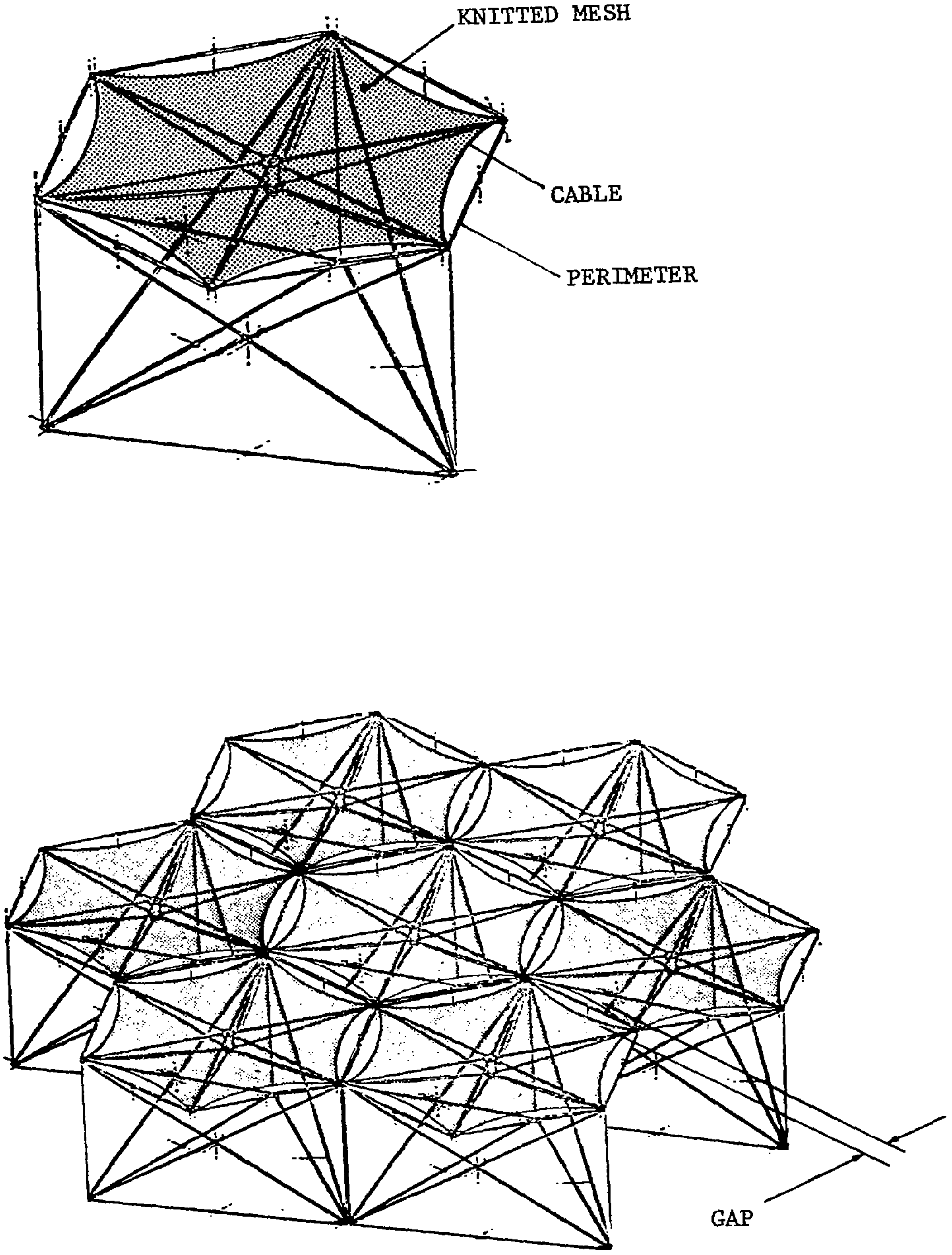


Figure 33. Knitted Mesh Module Configuration.

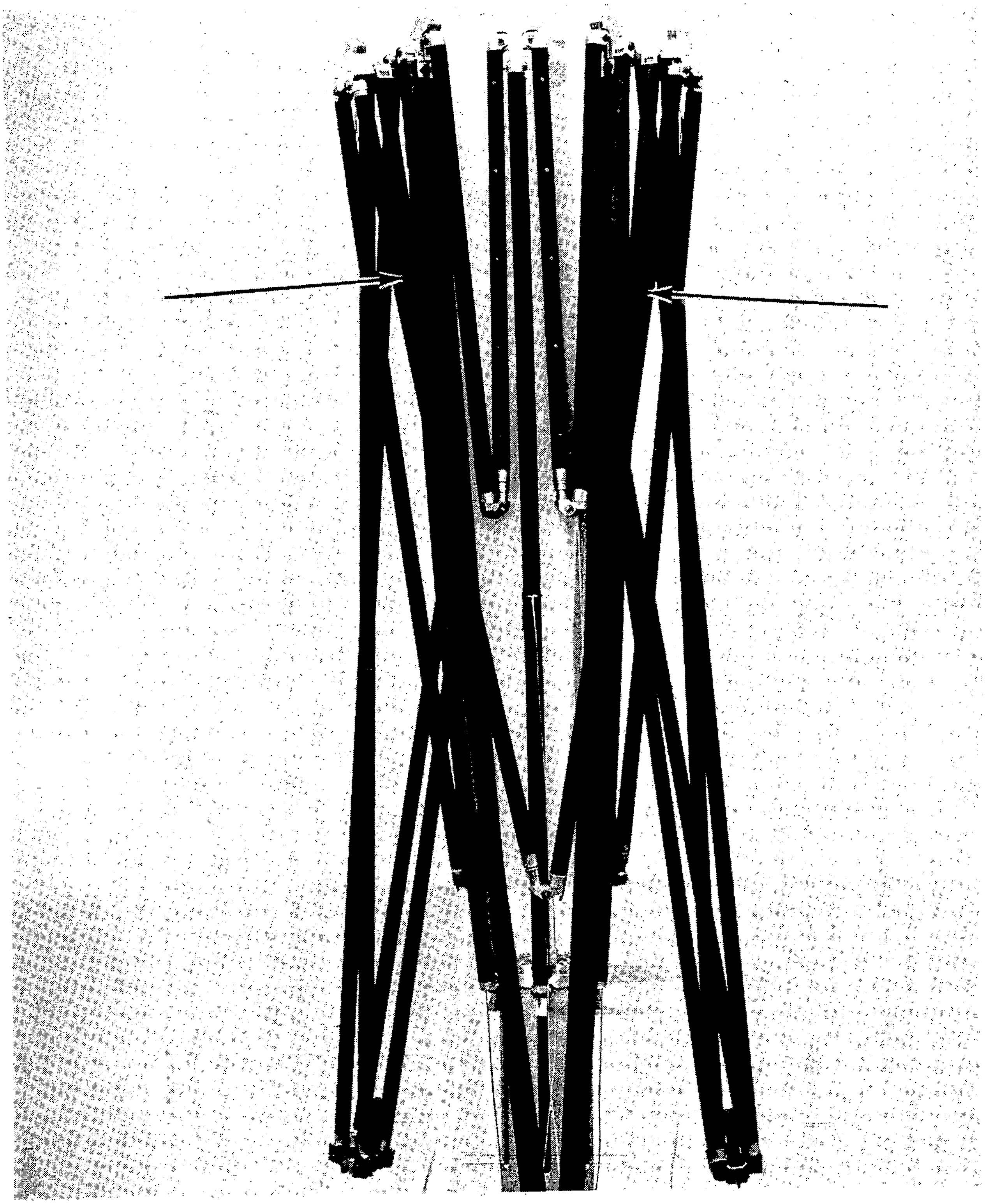


Figure 34. Stowed Model Showing Tube Interference

Initial deployments of the model also verified that in the early phase of deployment, the cross brace kinematics are such that each set of four arms must rotate about the upper joints for approximately 85 degrees (very nearly horizontal) before the lower arm corner fittings separate significantly from the upper joints. During this phase, or approximately the first 10 seconds of deployment, the weight of the links is such that the model's normal deployment forces are unable to rotate them against gravity, resulting in the arms hanging downward forcing the lower corner fittings up against the upper corner fittings as shown in Figure 35. Deployment must be interrupted at that point and the cross braces raised by hand against gravity to allow the lower corner fittings to deploy. Figure 36 shows the model after this operation. This action also required some means to control the cables being released from their storage spools to prevent tangling or binding. As an initial control, weights were used to provide a constant tension load on the cables, but were later replaced by adding spring loaded service loops to the cable runs. These service loops in the cables also served to eliminate variations in cable length due to uneven cable winding. The actual cable required on the spools was approximately 33 cm more than calculated for smooth winding and winding path differences caused length variations of $\pm$ 1 cm from deployment to deployment. This variation indicates the need, on full scale units, to either control the cable with winding guides similar to those used on fishing reels, or to use other flexible members (such as tapes) as substitutes for the cable whose spooling can be more exactly determined and controlled.

The final model limitation discovered was that the lower arms which form the folding lower truss members were unable to fully deploy against the force of gravity. The moment about the deployment hinge due to the weight of the arms in the horizontal position overpowers the deployment moment in the spring loaded hinge. This was overcome in the model by using a cord between each lower arm folded joint and its corresponding lower radial arm. As the model nears full deployment, these cords become

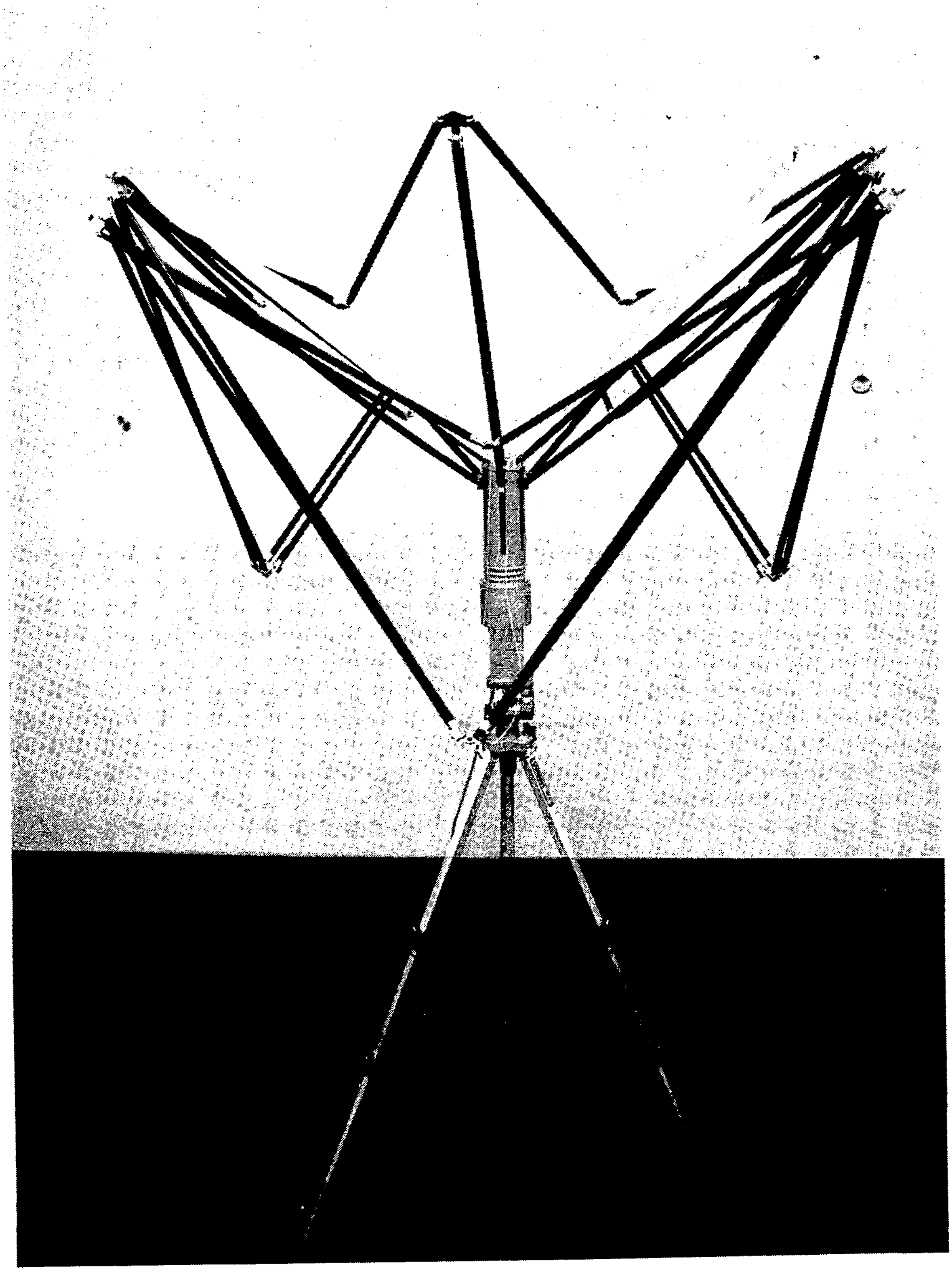


Figure 35. Partially Deployed Model
(Cross Brace Deployment Hindered by Gravity)

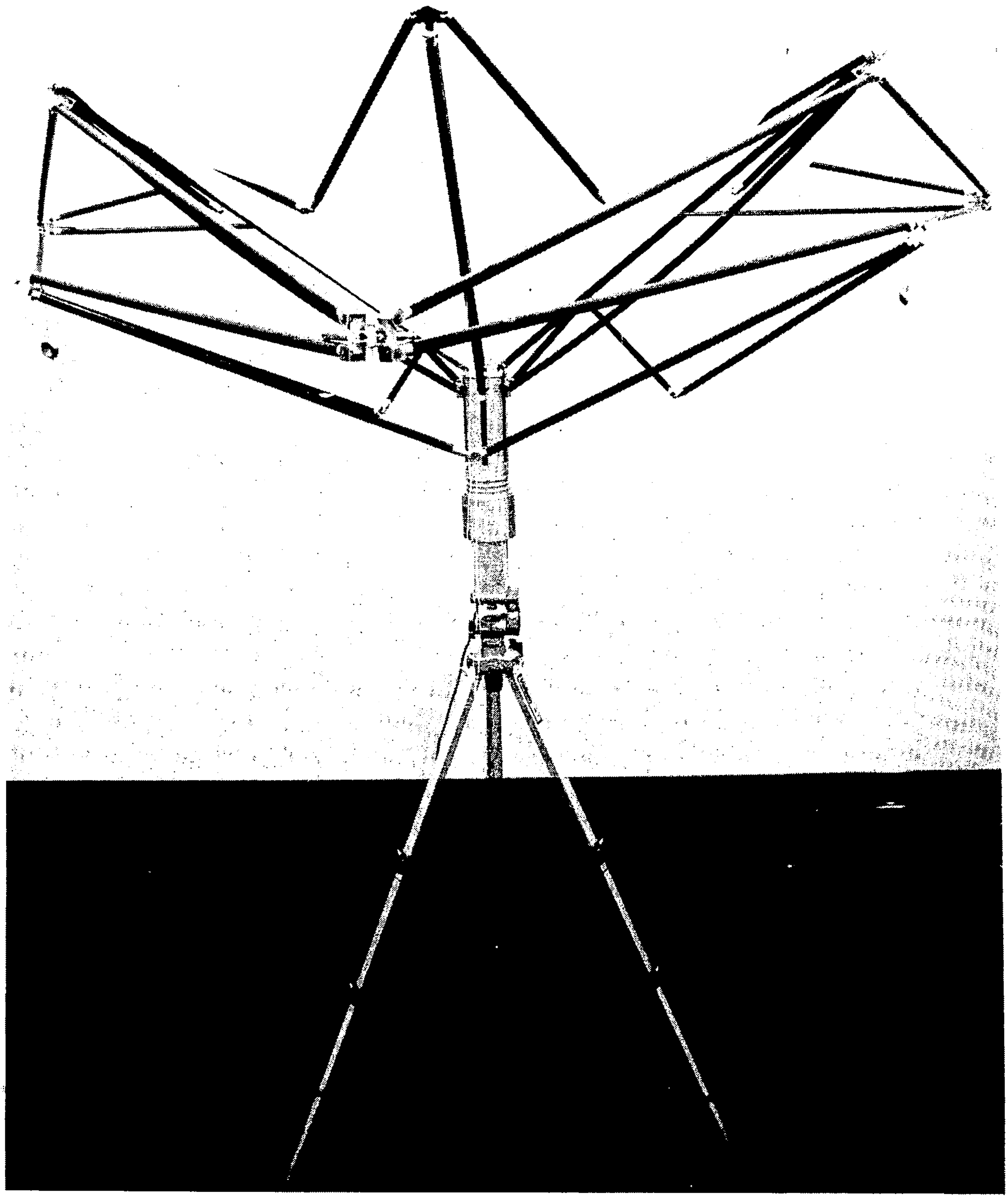


Figure 36. Partially Deployed Model (Cross Brace Raised to Allow Lower Arm Deployment).

taunt, relieving the weight from the arm allowing the spring loaded joint to deploy fully and latch.

The 1 g deployment difficulties encountered with the model are indicative of a class of problem which must be addressed during construction and test of full scale modules. Very light weight structures of this type are not capable of supporting themselves in a 1 g Earth environment. Construction of full scale modules will have to be performed in assembly structures which will support the members in undeflected quasi-zero g positions. This support will have to be maintained during stowage operations on the modules, and during any deployment testing. Thus it may well come to pass that structures of this size will be subjected to component testing only and that the initial deployment of the complete structure will be performed in orbit.

2.3.6 Model Weight Description. The Demonstration Model components were weighed after assembly. The component weight breakdown for the assembly is given in Table II. The weight of the deployment mechanism is not representative of flight hardware, and could be reduced by approximately 40%. If this were done, the total mass of the assembly would reduce to approximately 4.45 kg, and the joint mass fraction would be approximately 28%.

2.4 Full Scale Module Description

2.4.1 General Arrangement and Scaling Parameters. Applications for space antennas through the next decades point to requirements for very large (.5 - 1 km diameter) apertures operating at gigahertz frequencies. In order to launch such antennas economically, efficient methods for packaging these reflectors into the STS Orbiter cargo bay for launch are essential. The modular antenna concept shows significant promise for this application.

TABLE II DEMONSTRATION MODEL

WEIGHT BREAKDOWN

COMPONENT	NO. USED	MASS kg	(WT) (LB)	TOTAL MASS kg	(WT) (LB)
CENTRAL DEPLOYMENT MECHANISM	1	2.4	(5.25)	2.4	(5.25)
UPPER CORNER FITTING (6 ARM)	3	.04	(.09)	.12	(.27)
UPPER CORNER FITTING (4 ARM)	3	.035	(.08)	.11	(.24)
LOWER CORNER FITTING	3	.05	(.12)	.16	(.36)
MID BEAM PIVOT HINGE	9	.03	(.07)	.27	(.66)
CROSS BRACE CENTER HINGE	3	.05	(.11)	.15	(.33)
UPPER RADIAL ARMS	6	.04	(.08)	.23	(.51)
LOWER RADIAL ARMS	6	.04	(.09)	.24	(.53)
PERIMETER ARMS	12	.02	(.05)	.25	(.55)
LOWER STRUCTURE ARMS	6	.04	(.08)	.21	(.46)
CROSS BRACE STRUTS	12	.05	(.10)	.57	(1.25)
MESH	1	.15	(.34)	.15	(.34)
		TOTAL		4.86	(10.75)

The kinematics, joint concepts and deployment mechanism of the modular antenna demonstration model can be scaled directly to Orbiter cargo bay proportions. The only significant change required to produce a full scale antenna model is to increase the length of the individual struts. The useful size of the Orbiter cargo bay, after allowing room for Astronaut ingress/egress to the bay, is a cylinder 4.5 m (15 ft.) in diameter by 17.1 m (56 ft.) long. This limits the module size by constraining struts lengths to 17.1 m cargo bay length. This constraint leads to 28 meters across the corners of the hexagonal face as a maximum practicable module size compatible with STS launch. Figure 37 shows the general arrangement of such a module, and the resulting strut lengths, the longest of which is the 17.1 m (56.25 ft.) cross brace member. Buckling of the struts due to module loads is the only other size limiting parameter. A full load analysis for the module antenna structure was not performed since the design loads are mission peculiar. Such an analysis should be performed when a focus mission is defined.

2.4.2 Module Weight Breakdown. The modular antenna concept, in full scale versions, promises very efficient support structures for antenna reflector surfaces. A graph of module mass vs size is given in Figure 38, and component mass fractions vs size are shown in Figure 39. It can be seen that for a 28 m module the mass fraction of the module structure is 20%, increasing to 43% for a 10 meter module. A comparative mass fraction for a previous technology reflector (the ATS-6, 9.1 meter diameter reflector) is 91% structure.

2.4.3 Mesh Attachment. The attachment of the reflective mesh to the reflector supporting structure is of prime importance in reducing surface distortions, which in turn cause loss of overall antenna efficiency. Many different methods of securing the mesh to its support structure have been tried, and in general those methods which are simplest in concept, using the least number of differing types of materials, have proven best.

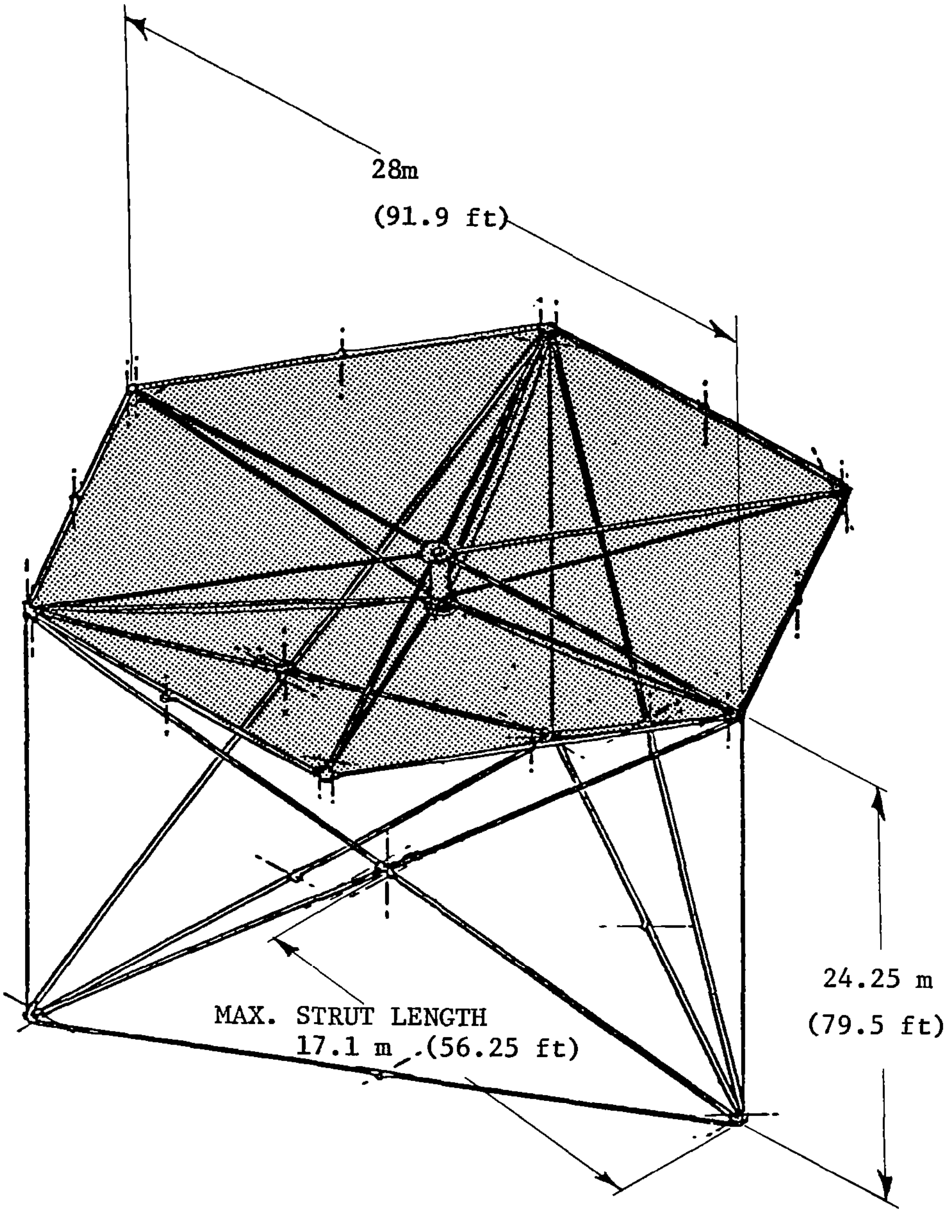


Figure 37. Maximum Size Module for STS Launch.

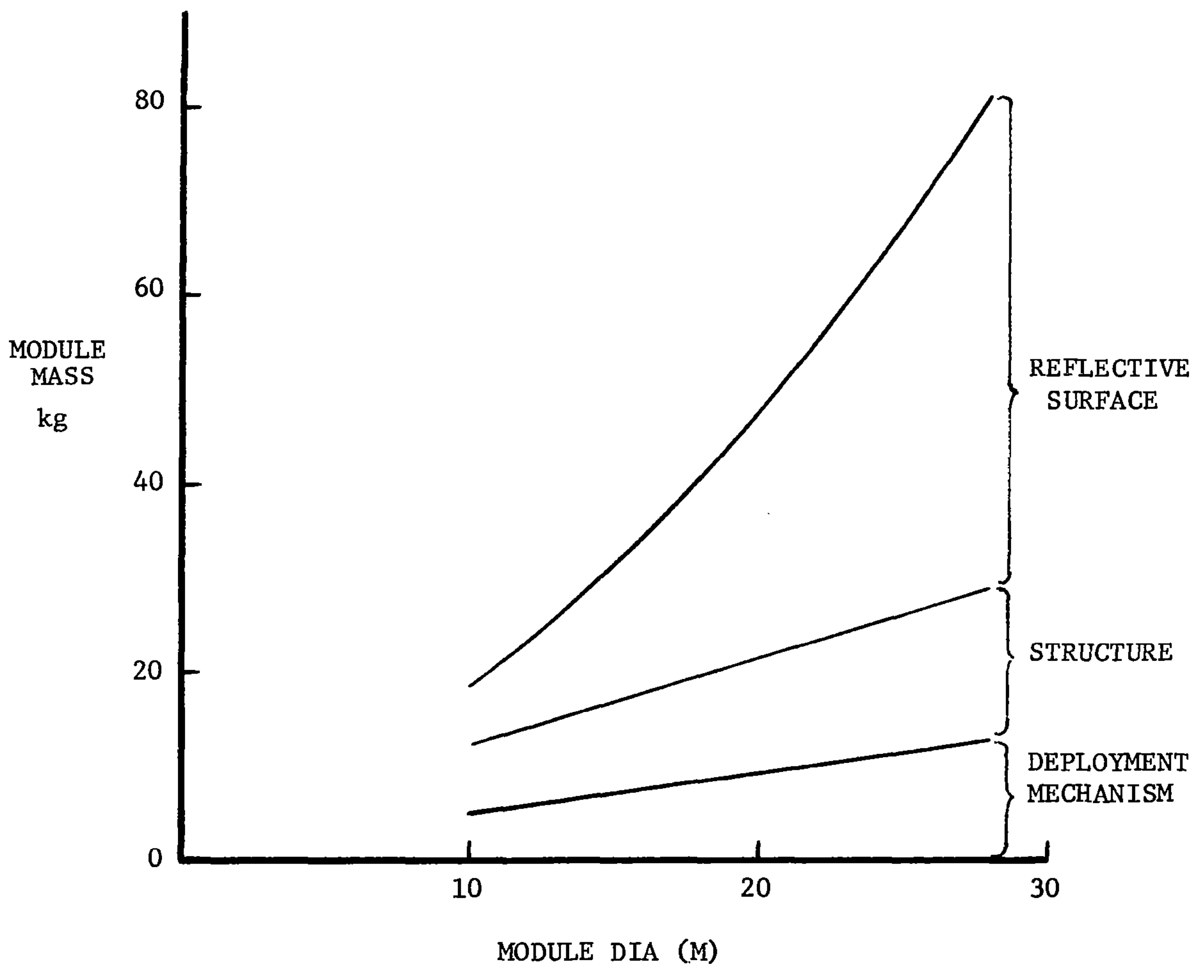


Figure 38. Module Mass vs Size.

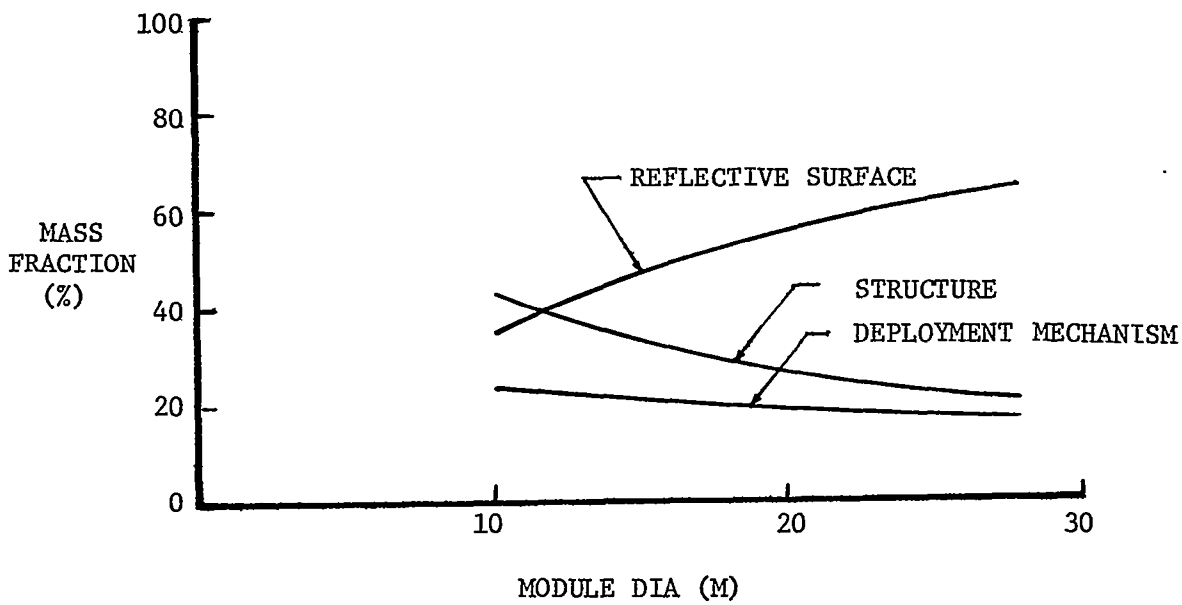


Figure 39. Module Component Mass Fractions vs Module Size.

Figure 40 demonstrates the method of attaching a mesh surface to the tops of the radial tubes. This method was employed on the demonstration model, and works satisfactorily. From the performance studies described in Section 3, it can be seen that higher frequencies of operation may be obtained, due to the closer approximation to a true paraboloid, by providing a curved standoff support for the mesh. Figure 41 describes the attachment method used with this type of support.

Closer approximation to the true paraboloid can also be obtained by using surface augmentation schemes which control the position of the reflective mesh as if the support structure consisted of more elements. Figure 42 describes two such approaches. Figure 42A depicts a reflective surface augmentation scheme using discrete attachment points at the center, mid-points, and ends of each radial arm and at the center of each perimeter arm. The mesh would be constrained along the connecting lines between these points using quartz tension cords. Figure 42B describes a similarly augmented surface but without the complexity of the tie points at the mid-points of the perimeter arms.

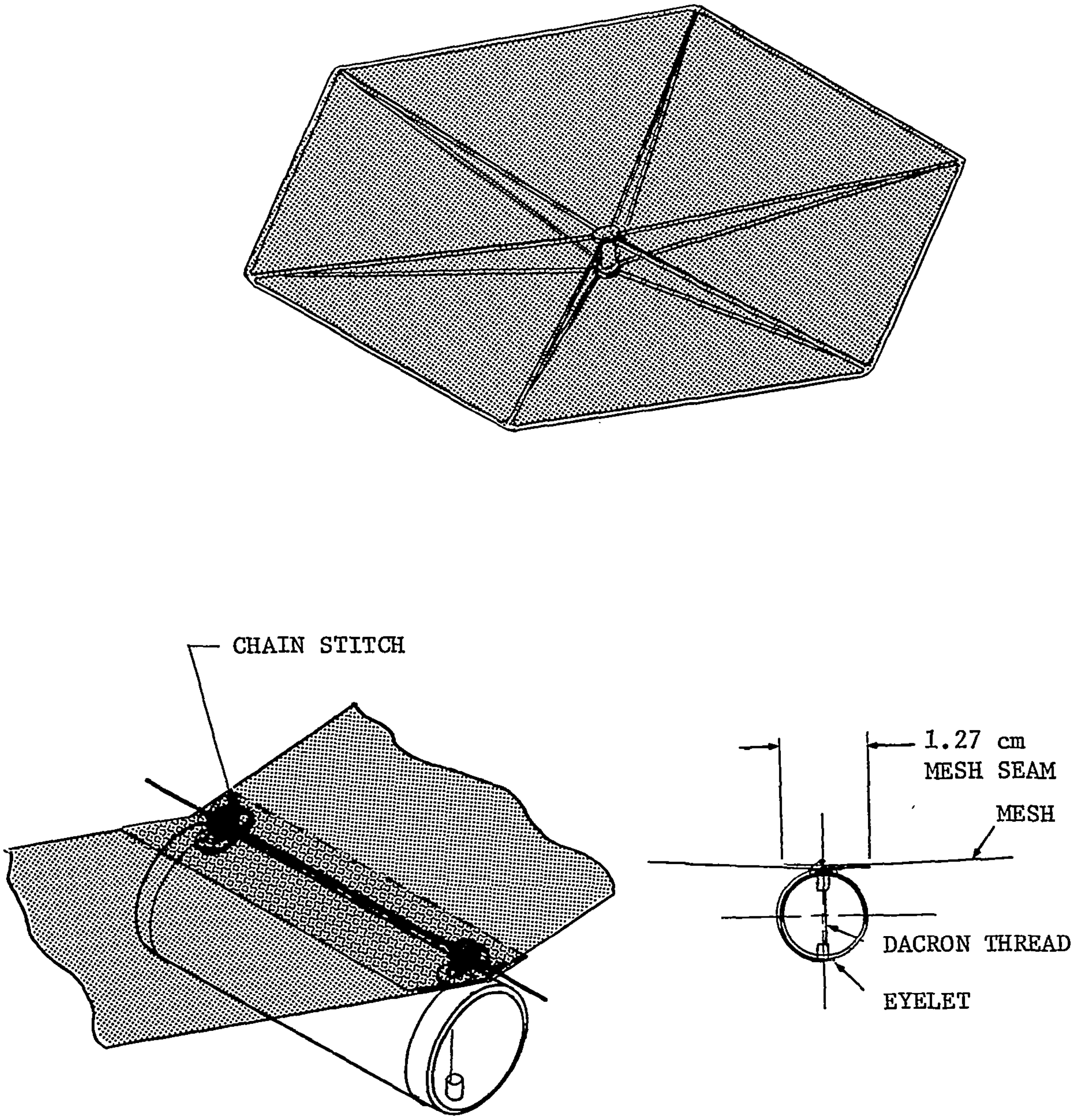


Figure 40. Mesh Attachment to Radial Tubes.

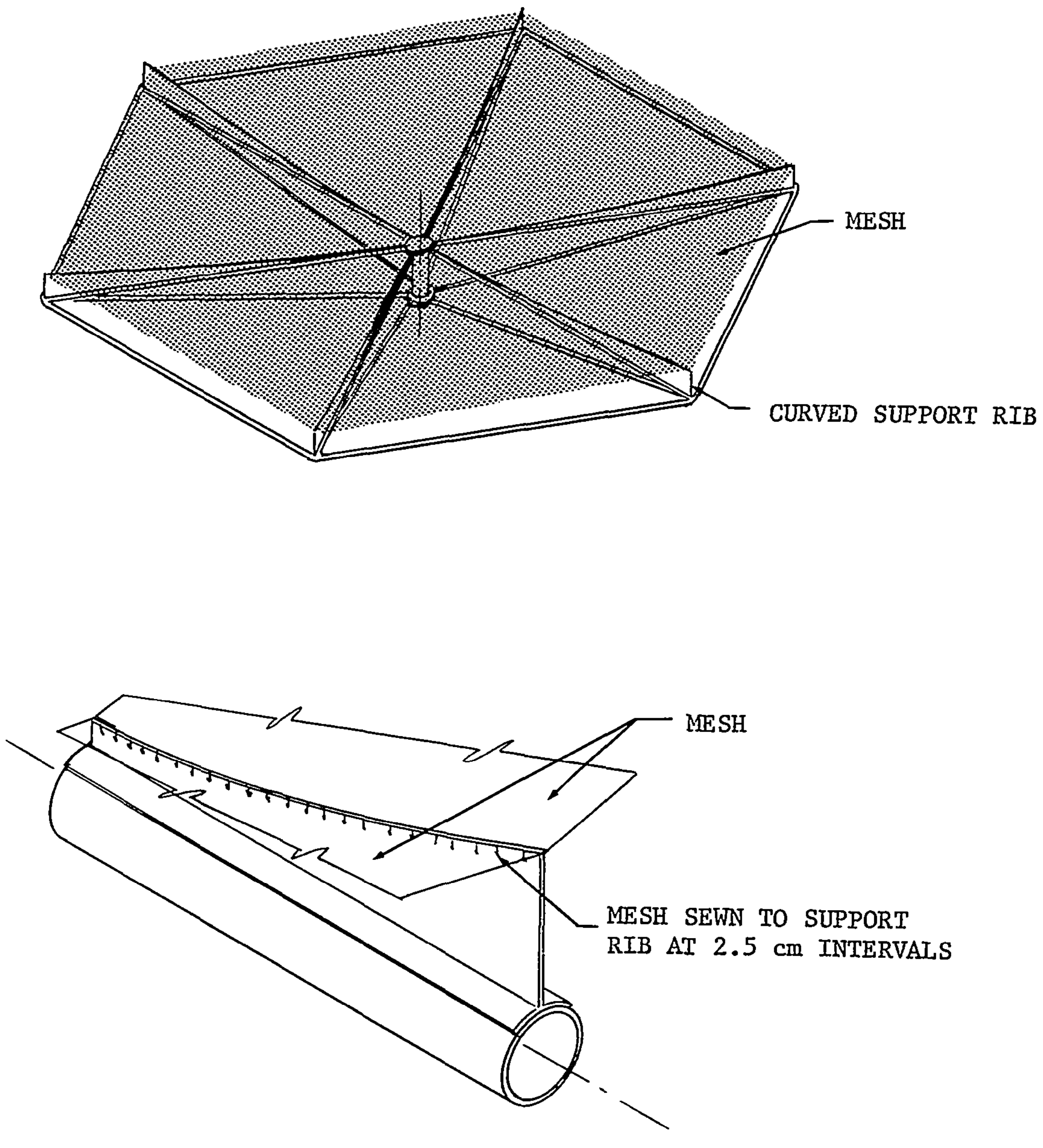
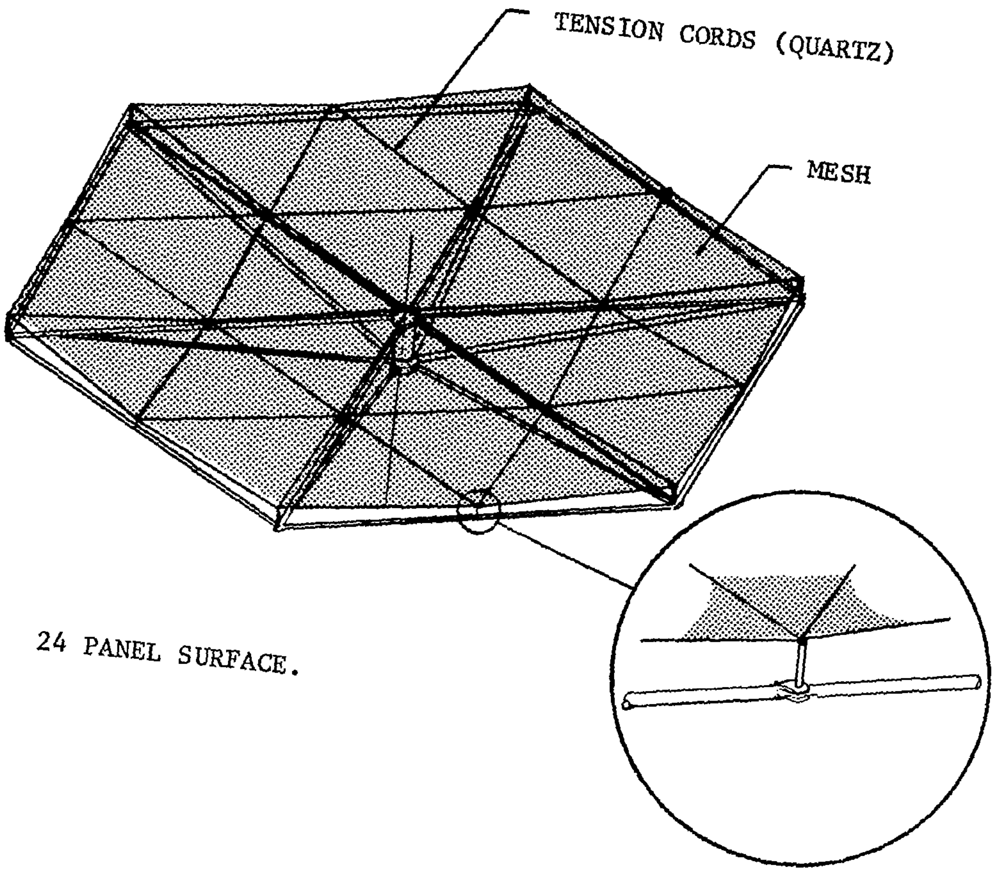
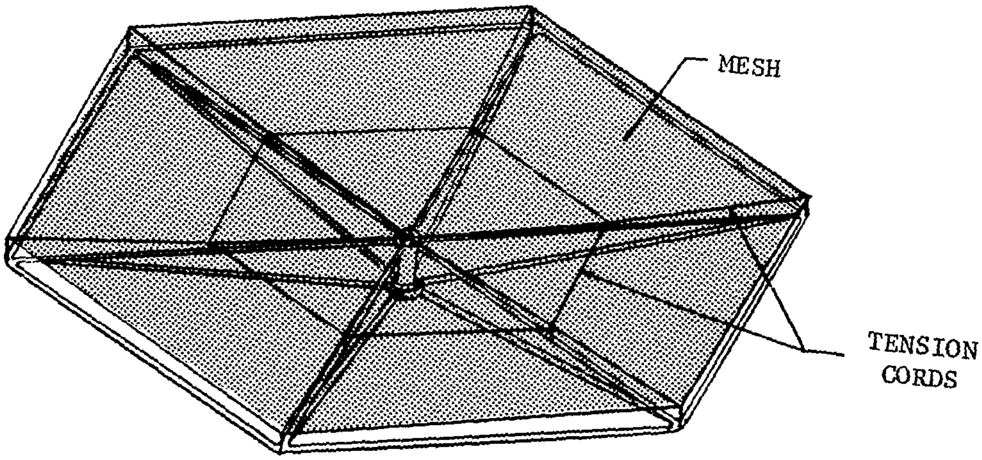


Figure 41. Mesh Attachment to Curved Standoff.



A. 24 PANEL SURFACE.



B. 12 PANEL SURFACE.

Figure 42. Surface Augmentation Methods Using Mesh Ties.

3.0 LARGE REFLECTOR STUDIES

3.1 Large Reflector Requirements

Major emphasis in the Aerospace Community is currently being placed on development of extremely large space systems for public benefit. NASA, specifically Goddard, Langley, and JPL, have announced plans to place parabolic and/or array antennas in space for use in public services, solar power transmission, radio astronomy and communications. These missions identify requirements for reflectors with apertures of up to 1000 meters.

The studies below estimate the radio frequency performance, module deployment, any joining techniques, and reflector assembly procedures applicable to the construction of these large space-borne reflectors.

3.2 Reflector Performance Studies

A parametric computer code has been prepared to define the RMS surface deviation for reflectors made up of large numbers of modules. The study used the module diameter, number of modules across the reflector face, and reflector focal length/diameter (f/D) ratio as input variables; and obtained RMS surface deviations as output. For this analysis, the basic six element module approximation (Figure 41) was used. These data are compiled as Appendix B to this report, and the data is graphed in Figures 43 through 46. Note that thermal distortions in the reflector are not included in these charts.

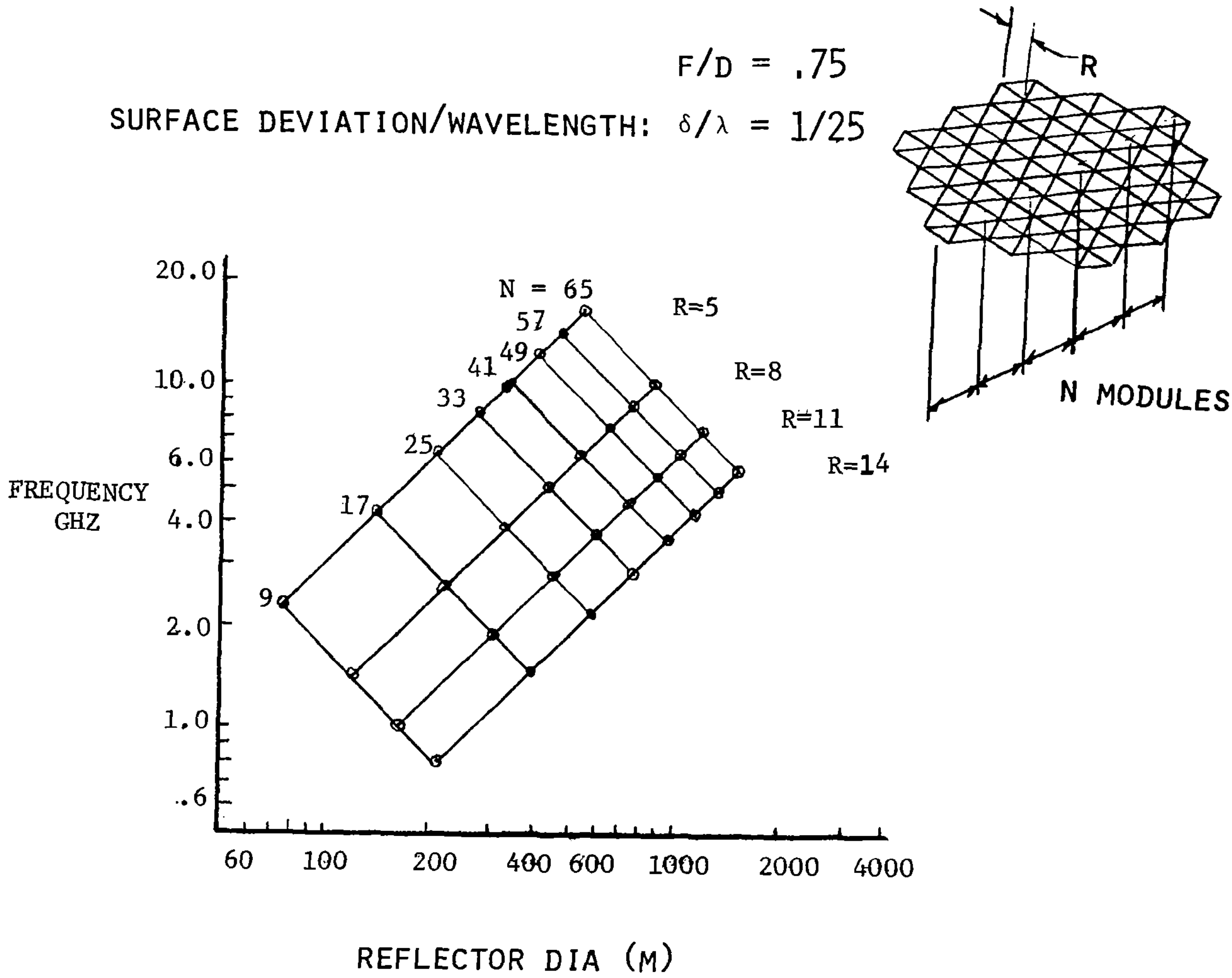


Figure 43. Reflector Frequency
vs
Size
(No Thermal Effects.)

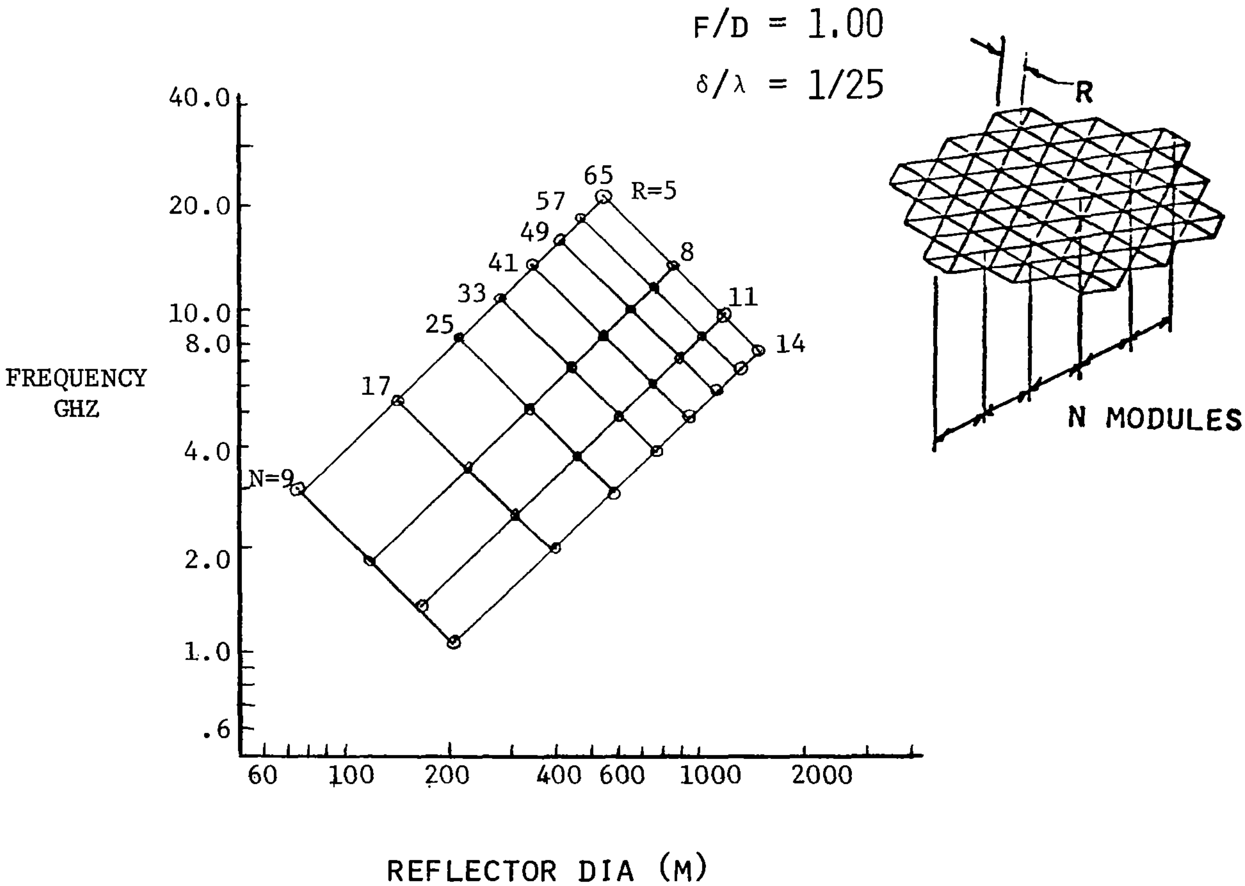


Figure 44. Reflector Frequency
vs
Size
(No Thermal Effects).

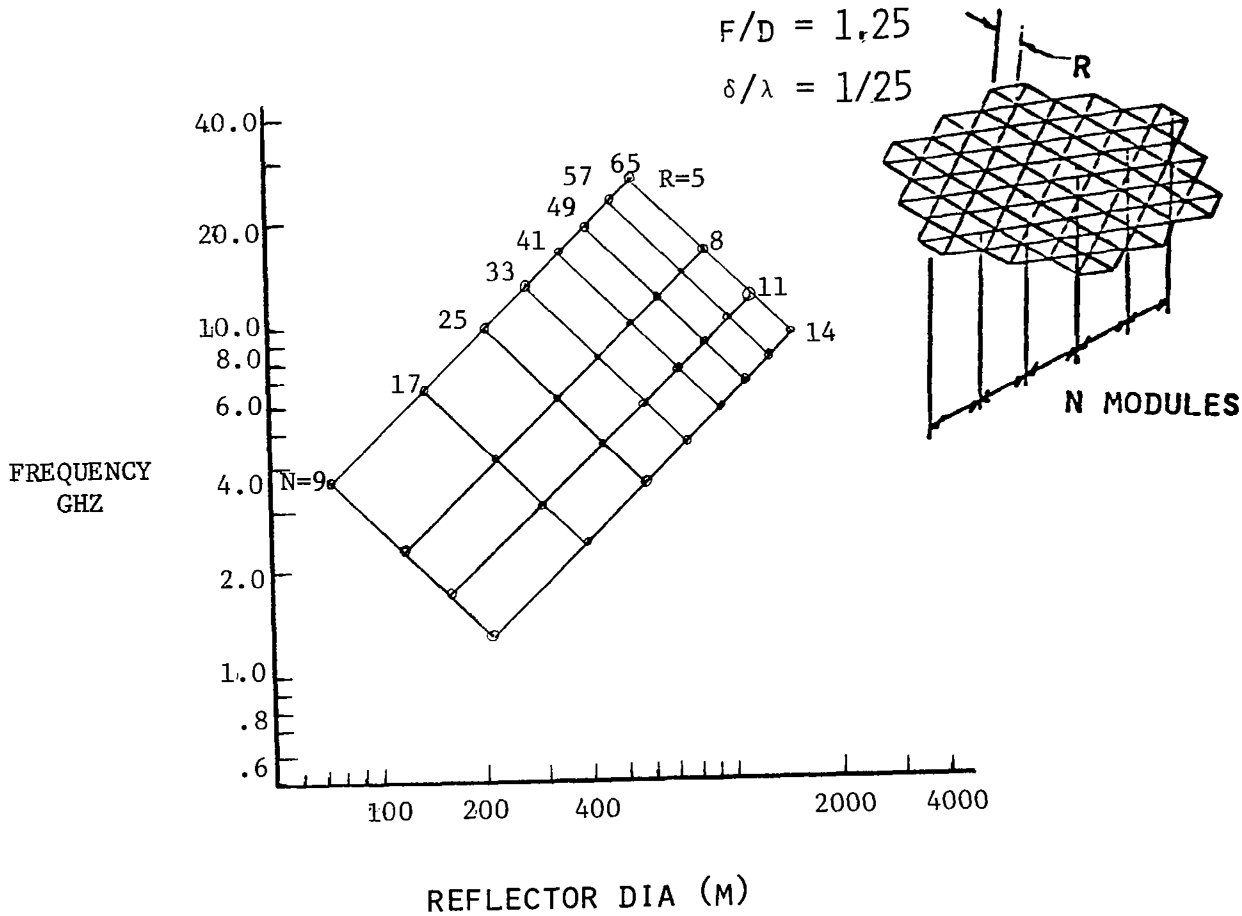


Figure 45. Reflector Frequency
vs
Size
(No Thermal Effects.)

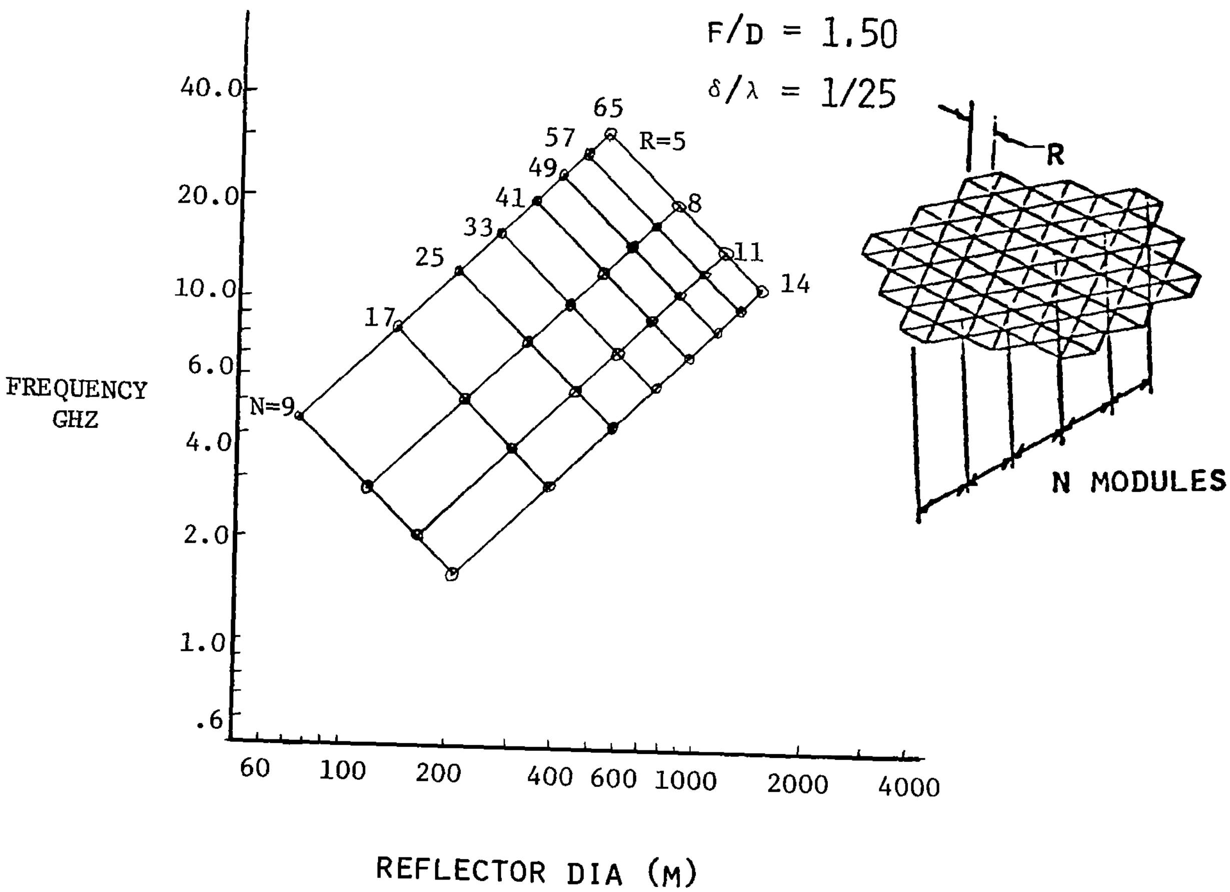


Figure 46. Reflector Frequency
vs
Size
(No Thermal Effects).

A finite element thermal distortion model was then prepared which modeled the upper surface in order to include the distortion effects of thermal gradients in the Gr/E tubes. The thermal analysis was performed using the program "STRESS" leased to Lockheed Corporation by Tymshare Inc. The program is designed to perform linear analysis of elastically loaded structures. It can analyze structures with prismatic members or plate members, in two or three dimensions, with pinned or rigid joints, and subjected to a wide variety of loads, support motions and temperature effects. The solution technique uses finite element technique based on displacement method. The thermal condition used for this analysis assumed that the module faced the Sun directly with the upper radial arms of the mesh support surface in Sun and the lower radial arms totally shaded by the upper arms, thus creating temperature differences between arms as well as thermal gradients across the individual tubes. Figures 47 through 50 depict operation size vs frequency including the effects of thermal distortion in the support structure.

3.3 Module Assembly Techniques

Erecting large antennas in space requires construction of large numbers of modules, packaging them for launch into Earth orbit, and deploying and assembling the completed modules in the space environment. Practical means of modifying and/or repairing these structures are also required to make such systems truly economical.

3.3.1 Module to Module Attachment. Attaching elements one to another to form larger assemblies will probably provide the largest single challenge to the construction of large space structures. Certainly the assembly task of connecting modules together to form large, extremely accurate reflector poses a major design challenge and imposes significant module design requirements. The basic requirements for module to module attachment joints are listed in Table III, and Figure 51 shows the location of the joints. Figure 52

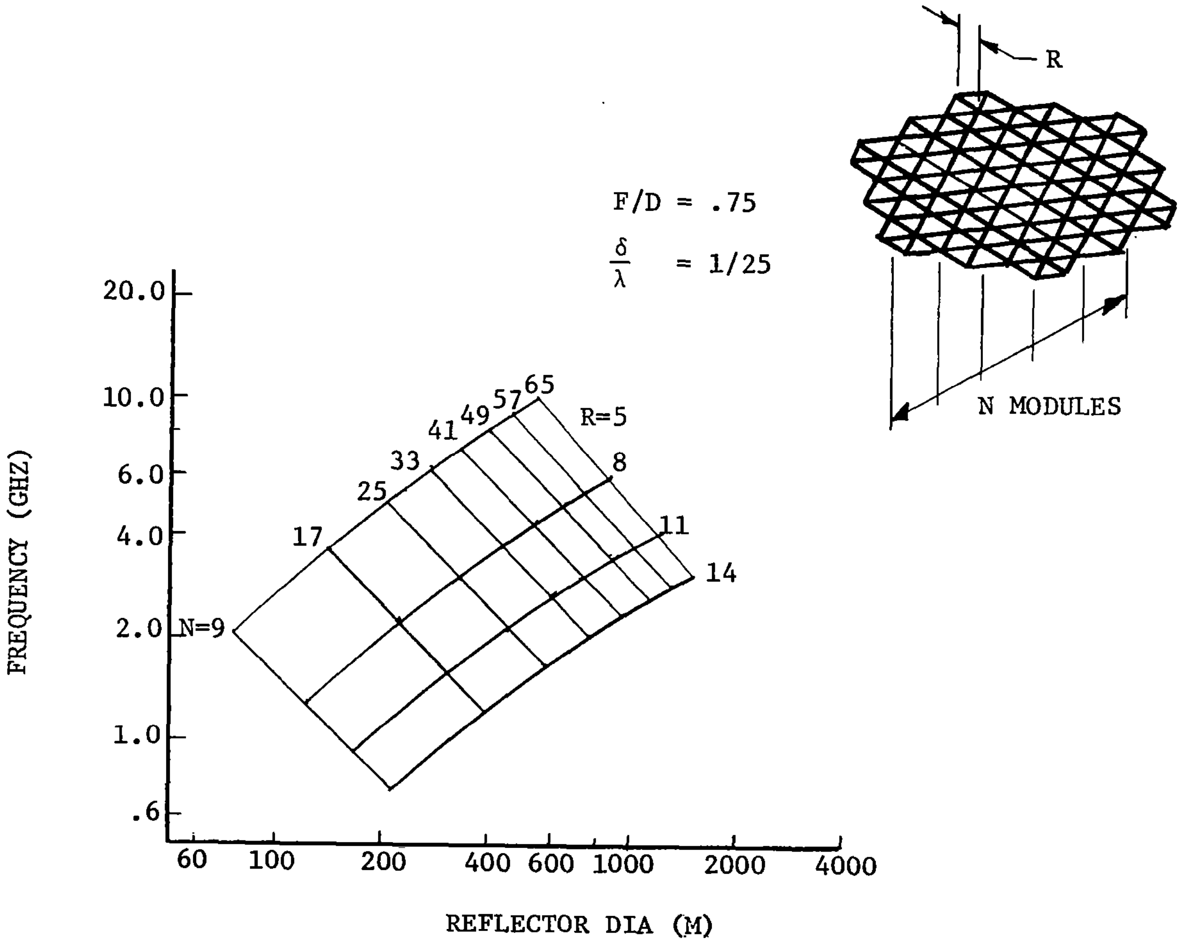


Figure 47. Reflector Frequency vs Size (Inc. Thermal Effects).

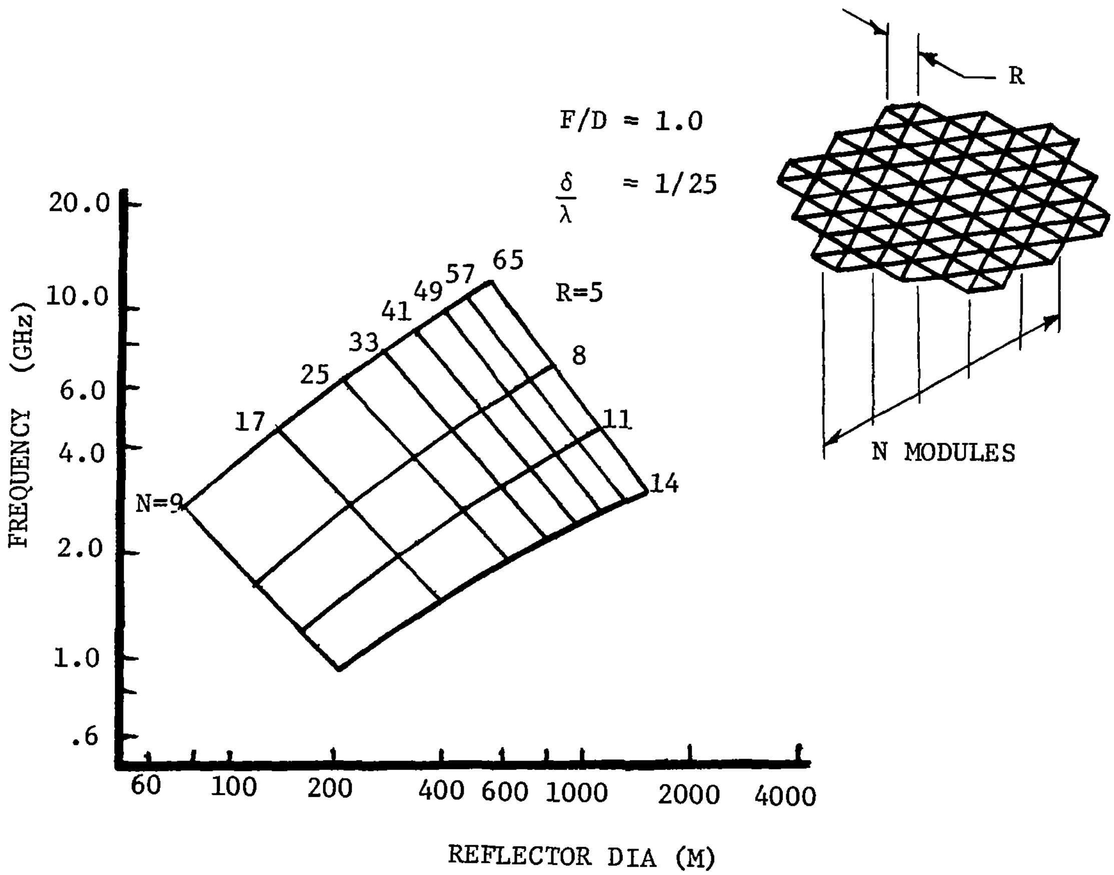


Figure 48. Reflector Frequency vs Size (Inc. Thermal Effects).

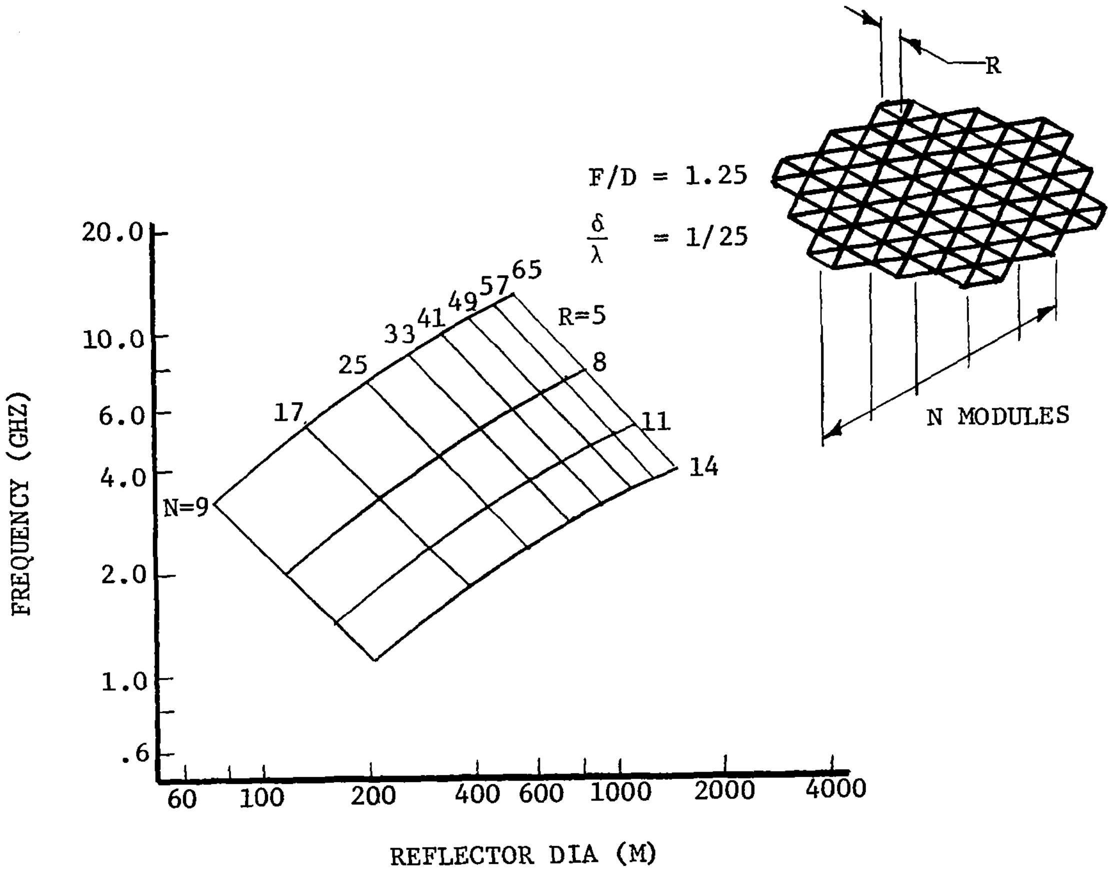


Figure 49. Reflector Frequency vs Size (Inc. Thermal Effects).

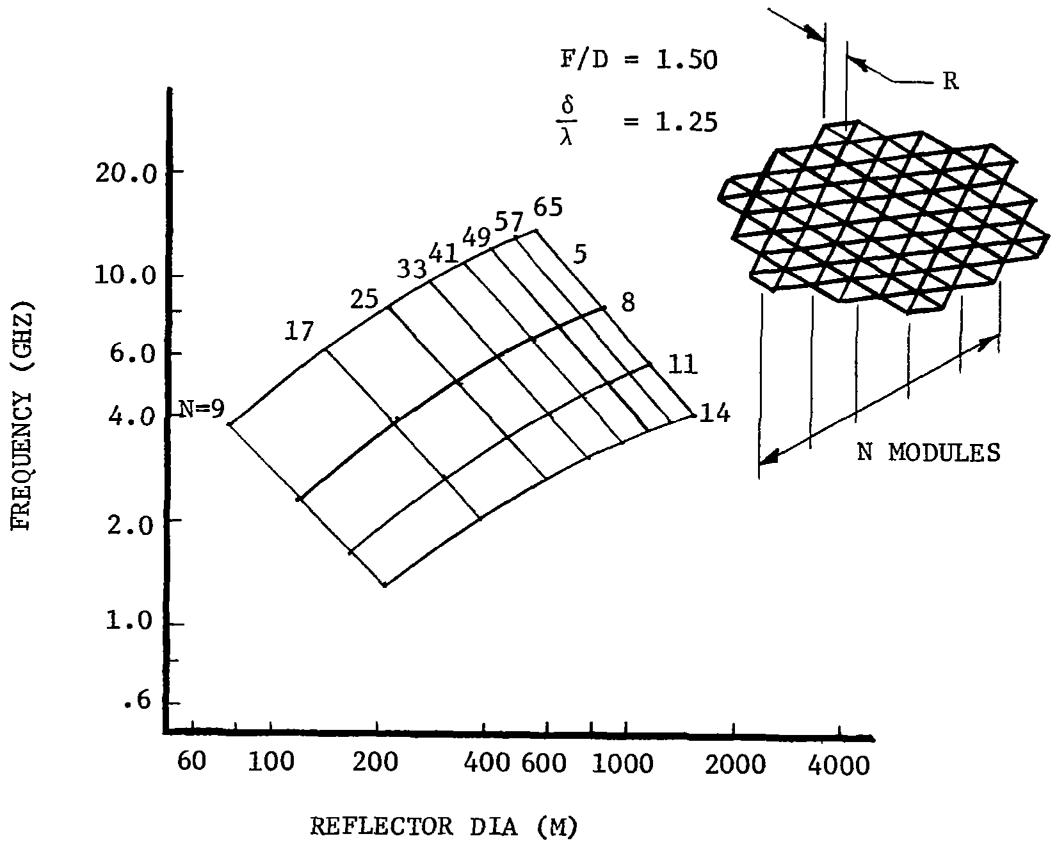


Figure 50. Reflector Frequency vs Size (Inc. Thermal Effects).

TABLE III DESIGN REQUIREMENTS

FOR MODULE TO MODULE ATTACHMENT JOINTS

- Joint must have no backlash or free play.
- Joint must allow for removal/replacement of one module in an assembled reflector.
- Joint must provide positive engagement and latching.
- Joint must be capable of being made and released by a space suited astronaut.
- Joint must be compatible with the module stow/deploy motions.
- Joint should allow for one time tolerance adjustment.
- Joint should be minimum size, mass and cost.

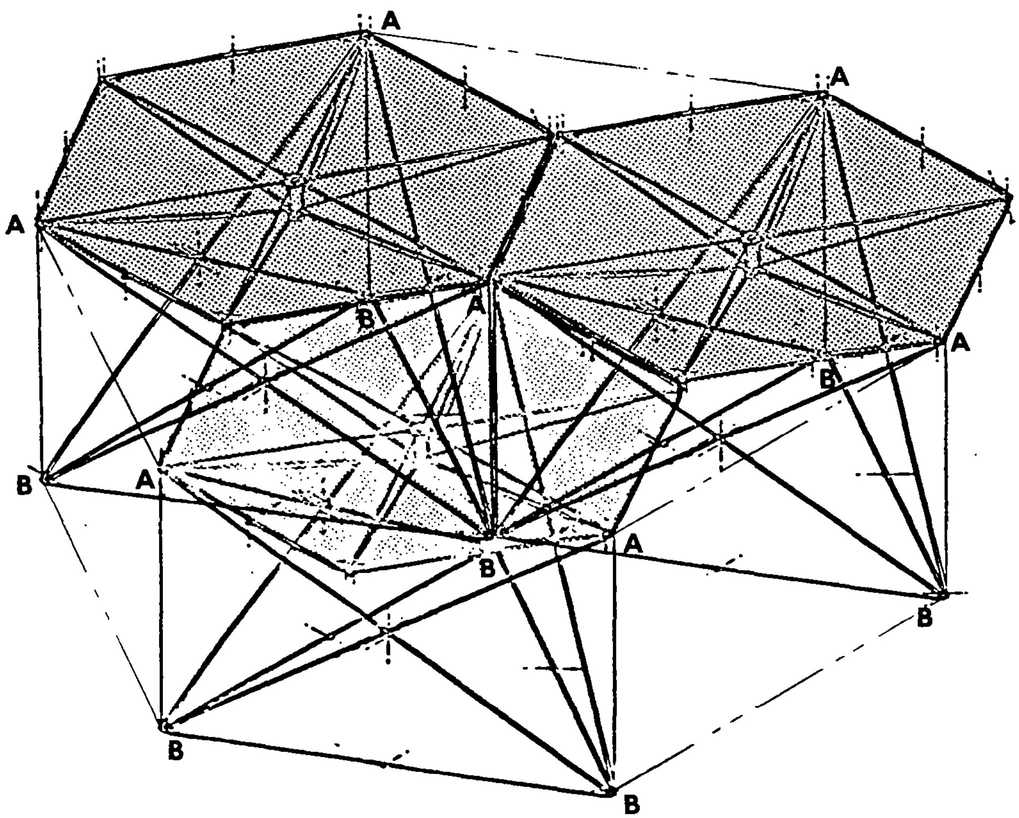


Figure 51. Module to Module Joint Locations.

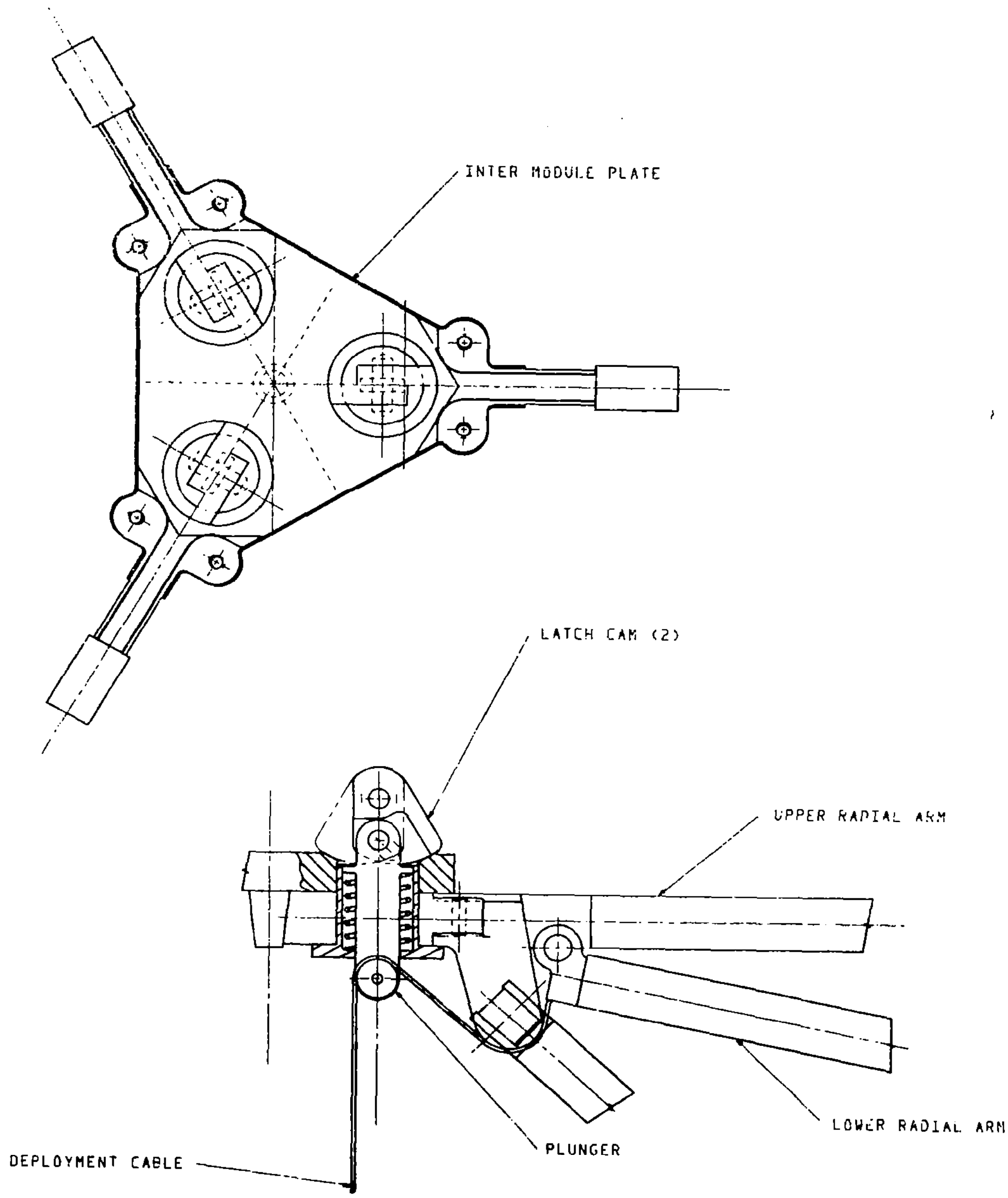


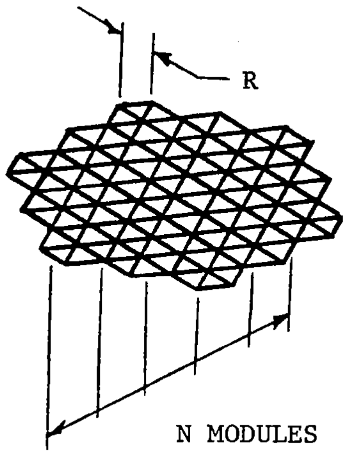
Figure 52. Module to Module Joint.

shows a design solution for the module to module attachment joints located at the corners of the reflective surface, those labeled "A" on Figure 51. The exclusive use of axial motions for activation and deactivation of the latch allows the module deployment cable to perform double service as a latch release cord. Mechanical advantages in the cam motions allow the module to be pushed into place and latched for installation. For removal, the cable is pulled, retracting the spring loaded plunger and retracking the latch cam. The wedging action of the cams against the conical seat and the edge of the module corner fitting against the center pin eliminate freeplay and provide a load path wheelbase through the joint. Other fastening devices, i.e., quarter turn fasteners, screw threads, could be used to attach each module to the cap plate, but they would require close approach by an astronaut to release the module. Using the cable release, an astronaut can perform the attachment release for both joints at each module corner from the base end of the structure, thus saving valuable EVA time and eliminating any danger associated with operating a man in close proximity to the reflective mesh.

3.3.2 Module Packaging for Launch. Packaging studies for modules in the STS Orbiter have been performed to obtain (a) the maximum size antenna reflector that can be transported in a given number of shuttle payloads, and (b) a concept for packing the stowed modules in the STS Orbiter cargo bay.

Table IV lists the number of modules necessary to complete reflectors made up of rings of modules surrounding a central module. To assemble a symmetrical reflector of increasing size, it is necessary to pack specific numbers of modules which correspond to complete rings. The table also lists the number of shuttle flights required to transport the required number of modules to orbit for assembly, assuming that they can be packaged for launch in a 25 cm diameter circle.

TABLE IV MODULE COUNT FOR INCREASING SIZE



NUMBER OF MODULES ACROSS DIAMETER OR REFLECTOR	TOTAL MODULES IN REFLECTOR	NUMBER OF SHUTTLE FLIGHTS REQUIRED
1	1	1
3	7	1
5	19	1
7	37	1
9	61	1
11	91	1
13	127	1
15	169	1
17	217	1
19	271	1
21	331	1

TABLE IV MODULE COUNT FOR INCREASING SIZE (CONCLUDED)

NUMBER OF MODULES ACROSS DIAMETER OR REFLECTOR	TOTAL MODULES IN REFLECTOR	NUMBER OF SHUTTLE FLIGHTS REQUIRED
23	397	2
25	469	2
27	547	2
29	631	2
31	721	3
33	817	3
35	919	3
37	1027	4
39	1141	4
41	1261	4
43	1387	5
45	1519	5
47	1657	6
49	1801	6
51	1951	6
53	2167	7
55	2167	7
55	2269	7
57	2437	8
59	2611	8
61	2791	9
63	2977	10
65	3169	10

The module stowed package size is primarily dependent upon the diameter of the structural tubes and clearance allowances in the pivot joints to provide stowing space for the lower structure tubes. The tube stowing clearances are in turn dependent upon the dihedral angle of the structural cross members, which can be varied to control the overall structural depth of the module. A semi-emperical equation has been developed which relates stowed package diameter to module geometry and tubing diameter. For tube sizes and module geometries near those used in this study. the relation is:

$$D = 2 \sqrt{\left[\frac{3d}{2 \sin (30)} + \frac{(2d + .5) \sin \alpha}{\tan \theta} + 1.1\ d\right]^2 + [2.23\ d + .5]^2}$$

where D = package diameter - cm

d = tube diameter - cm

α = inclination angle of cross members to mast surface plane

θ = true angle between cross members measured at the upper joints

for the model cross member geometry chosen:

$$D = 2 \sqrt{[8.059\ d + .9898]^2 + [2.23\ d + .5]^2}$$

The requirements for a packaging framework to transport modules in the Orbiter cargo bay are listed in Table V. An isometric sketch of such a frame is shown in Figure 53. It consists of a number of longitudinal stringers connecting cradle sections which support the individual modules. The cradles are opened sequentially to allow the framework to dispense modules singly. Using this transport frame approach, it is possible to deploy and connect modules sequentially into reflectors of essentially unlimited aperture, by bringing more modules to the assembly site on subsequent Orbiter flights.

TABLE V MODULE PACKAGING FRAME

DESIGN REQUIREMENTS

- The frame must support all the modules through the STS launch environment.
- The frame must release modules individually for deployment, assembly.
- The frame must present no hazard to space suited astronauts when full, empty, or partially filled.
- The frame should be removable from the cargo bay while fully loaded with modules.
- The frame should be transportable in the shuttle bay when empty.

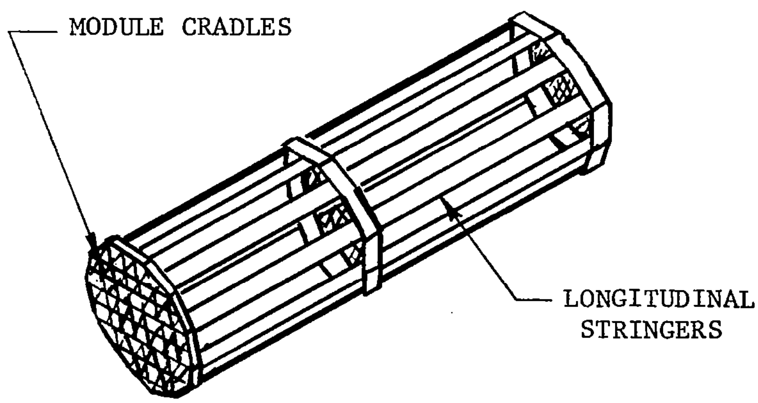
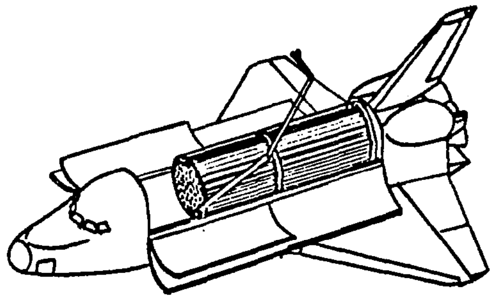


Figure 53. Module Packaging Framework.

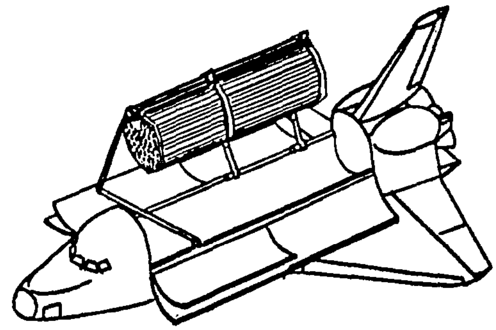
Modules are delivered to orbit in the following manner, as described in Figure 54. The loaded cannister is placed into the Orbiter cargo bay. When the Orbiter achieves the desired orbit the cargo bay doors are opened and the module cannister relocated above the cargo bay as shown in Figure 54A and B. The Payload Installation and Deployment Aide (PIDA) being developed by Johnson Space Center or an equivalent handling system can be used to affect this position change. The Orbiter RMS is then used to grasp the first module by its deployment jackscrew drive. The module cannister is designed to open sequentially and release one module at a time from its support frames. The RMS is then used to position the module away from the Orbiter and to deploy the module as shown in C. Once the module has been deployed it can be released by the RMS to be installed into a reflector assembly, D. As additional modules are deployed, the cannister structure is opened sequentially to release additional modules one at a time for deployment. The latching elements of the structure open by pivoting back against the remaining latched cannister segments to provide sufficient clearance for removal of the released module. Thus, as each row of modules is deployed, access is automatically provided to the next row of modules. After the last module is deployed, E, the cannister framework is closed and returned to the cargo bay by the PIDA, F, for return to Earth.

3.4 Reflector Assembly Scenarios

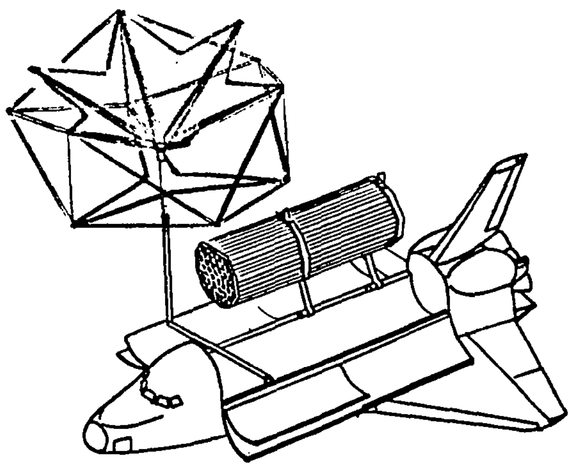
The final task required in developing large modular structures is the on orbit assembly of the total reflector from individual components. This study has identified five primary assembly procedures, and defined strengths and weaknesses among them. Primary requirements for any assembly scenario are that all required components be STS transportable, that the assembly be structurally stable throughout the construction phase, that parasitic structure be minimized, and that EVA be used only for cost effective procedures.



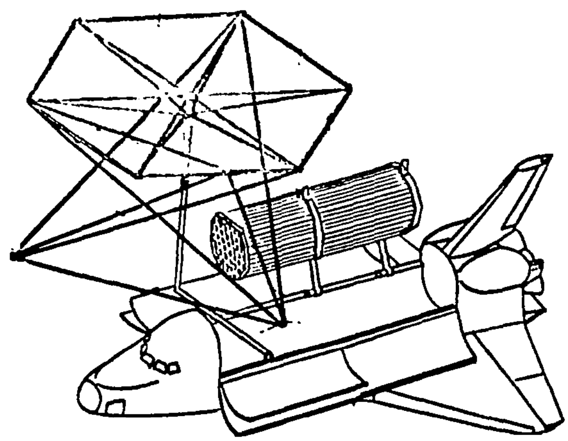
A. SHUTTLE ORBITER IN DEPLOYMENT ORBIT.



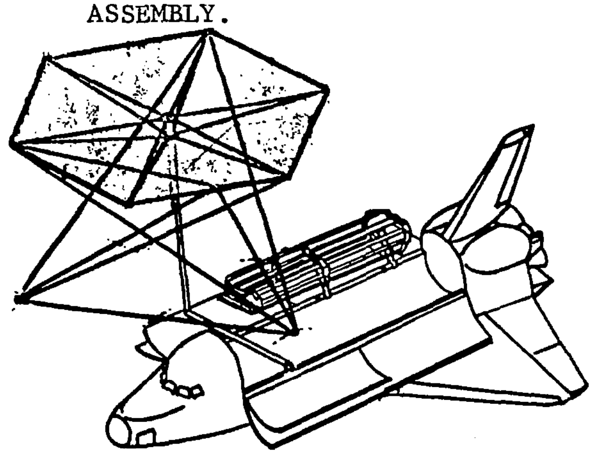
B. MODULE CANNISTER DEPLOYED BY PIDA OR EQUIVALENT PAYLOAD HANDLING MECHANISM.



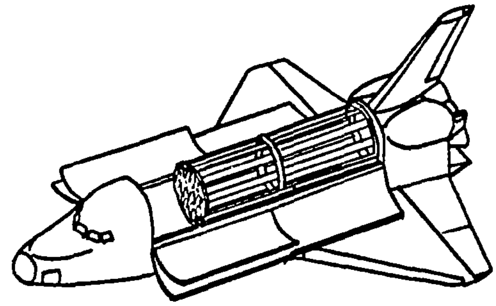
C. FIRST MODULE DEPLOYED AND READY FOR HANDOFF TO REFLECTOR ASSEMBLY.



D. FIRST MODULE REMOVED FROM CANNISTER AND BEING DEPLOYED.



E. LAST MODULE DEPLOYED AND READY FOR HANDOFF TO REFLECTOR ASSEMBLY.



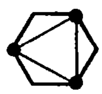
F. MODULE CANNISTER RECLOSED AND REPACKED INTO ORBITER CARGO BAY FOR RETURN TO EARTH.

Figure 54. Module Deployment Scenario.

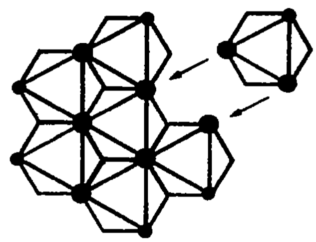
The basic assembly sequence assumed for the study is depicted in Figure 55. First, a central module is deployed, and then a ring of six modules is attached around its perimeter as shown. Additional rings of modules are simply added to the structure circumferentially around its perimeter as shown.

The simplest assembly procedure available on the space shuttle orbiter involves the use of the STS provided Remote Manipulator System (RMS) for module deployment and assembly. Figure 56 shows such an assembly. In this assembly scenario, the shuttle, equipped with two RMS arms and loaded with reflector modules is launched and achieves the desired assembly orbit. The cargo bay doors are opened and the RMS arms deployed. One arm removes the center module from the storage frame, positions it clear of the Orbiter, and deploys it. The second RMS arm then removes a second module, deploys it, and then brings the second module to the center module and either attaches the module directly or positions it in close proximity so that the final connection can be made by an astronaut. After this attachment is complete the second RMS arm removes a third module from the storage frame, deploys it, and moves it to be connected to the other two. The first RMS arm meanwhile rotates the assembly, if required, to allow access for the incoming modules. The process is continued until the reflector is complete.

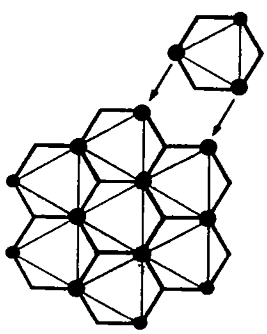
This assembly procedure is limited to reflector sizes of less than approximately 73 meters by the total reach of the RMS arms. To assemble larger reflectors the assembly would have to be "handed off" back and forth between the two RMS arms to always be able to arrange the next installation position at a point where the remaining arm could install the next module. In addition, the position placement accuracy of the RMS arms is not currently compatible with the module positioning requirements for installation without astronaut aid.



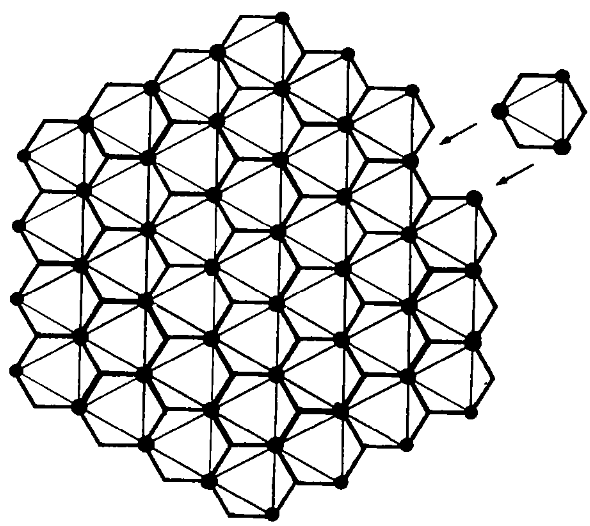
A. CENTRAL MODULE DEPLOYMENT



B. 1st PERIMETER RING INSTALLED

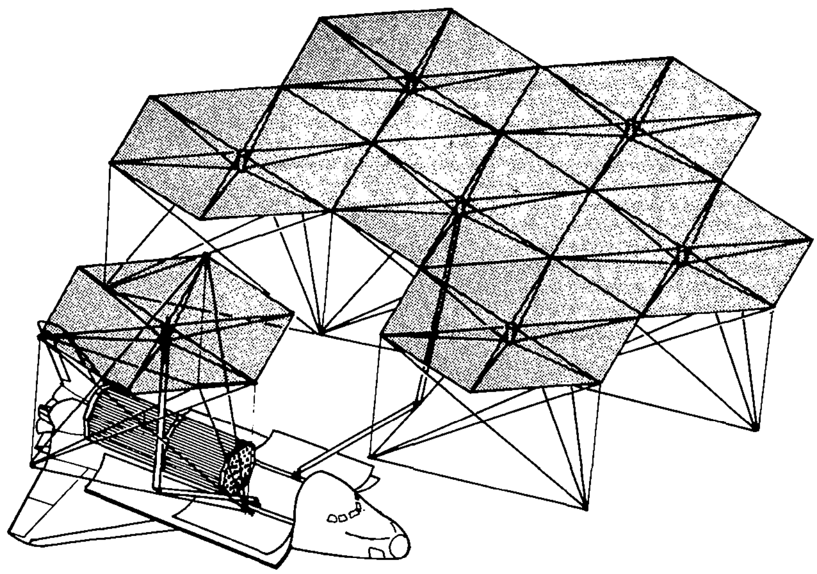


C. 2nd PERIMETER RING BEGUN



D. ADDITIONAL MODULES ADDED CIRCUMFERENTIALLY

Figure 55. Modular Reflector Assembly Order.



METHOD

USE TWO RMS'S IN THE ORBITER

PHILOSOPHY

ONE RMS HOLDS AND POSITIONS THE REFLECTOR ASSEMBLY AND THE SECOND RMS DEPLOYS AND INSTALLS ADDITIONAL MODULES

Figure 56. Modular Antenna Assembly Scenario.

The second assembly procedure investigated is depicted in Figure 57. In this concept an extendable assembly boom is used to hold the reflector assembly, the standard RMS arm is used to remove modules from the storage cannister and deploy them, and astronauts equipped with Manned Maneuvering Units (MMU) transfer the deployed modules from the RMS arm to the reflector. In sequence, the Orbiter achieves orbit, opens the cargo bay and deploys the RMS arm, the reflector assembly boom and module cannister. As each module is deployed, it is removed from the RMS arm by an MMU equipped astronaut, who transports the module to its proper assembly position in the reflector. The module is then installed by two astronauts, one operating the front reflective surface attachments and one connecting the rear surface attachments. As each module is being installed, a third astronaut controlling the RMS arm from within the Orbiter removes the next module from the storage cannister and deploys it, preparing it for pickup and transfer to the reflector assembly. When the reflector is complete, the assembly boom can either be removed from the reflector, retracted and returned to Earth with the Shuttle, or left with the reflector as part of the feed support tower.

This assembly scenario is essentially limited to the maximum diameter reflector transportable in one shuttle flight (approximately 310 m) unless docking provisions with the assembly boom are provided. While the shuttle cargo bay can hold enough modules, 330, to construct a reflector approximately 475 m across the corners, if volume is allocated for an assembly fixture and/or feed mast, the maximum practical reflector diameter for a single launch drops to approximately 310 meters. The transfer of modules from the RMS to the assembly requires extensive EVA by Astronauts.

The third assembly scenario attempts to ease the astronaut's work level by articulating the assembly boom. This approach, shown in Figure 58, differs significantly from the previous scenario only in the construction of the assembly boom. In this case, the reflector assembly can be rotated and tilted at its attachment point on the boom, and the

METHOD

USE RMS AND ASTRONAUT TO INSTALL
MODULES ONTO DEPLOYABLE BOOM

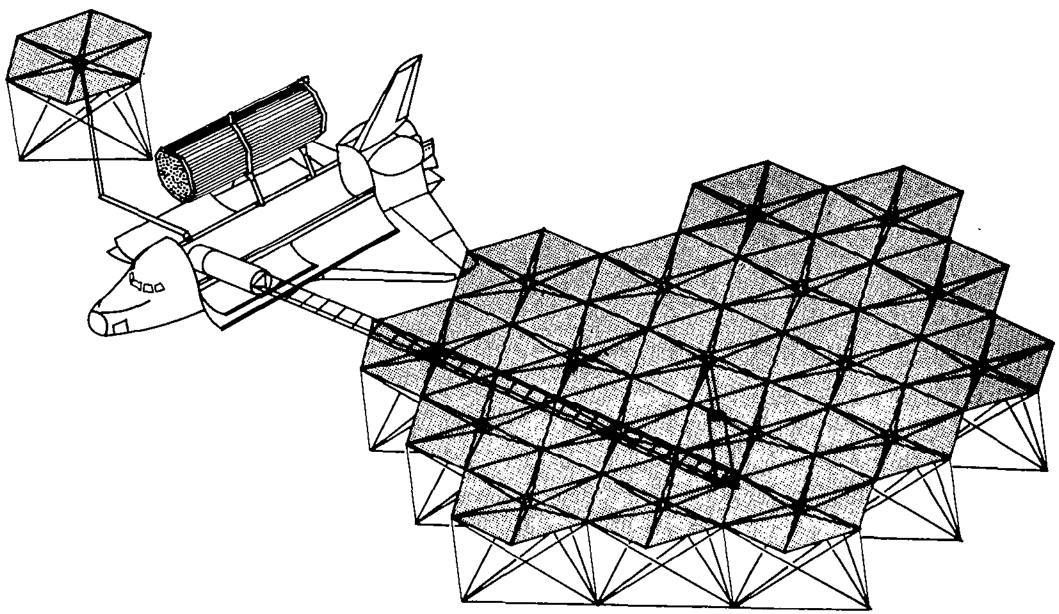


Figure 57. Modular Antenna Assembly Scenario.

PHILOSOPHY

AN ASSEMBLY BOOM IS DEPLOYED FROM THE ORBITER.
THE RMS HOLDS EACH MODULE FOR DEPLOYMENT, AFTER
WHICH ASTRONAUTS TRANSPORT IT TO THE ASSEMBLY
USING MMU

boom can be extended and retracted during the assembly process. The actual construction process is identical to that of scenario 2, but since the partially completed reflector can be rotated and tilted to position the next sequential module attach point next to the Orbiter cargo bay, astronaut travel time transporting modules is minimized. In fact, using the RMS and articulated boom, an operator located within the shuttle can position each module within a meter of its final installation position. The astronaut them performs the final alignment and makes the connector attachments. This assembly method suffers the same reflector size limitations (approximately 310 m) as scenario 2, but the astronaut EVA work is considerably reduced, and possibly eliminated if the RMS arm positioning accuracy can be improved.

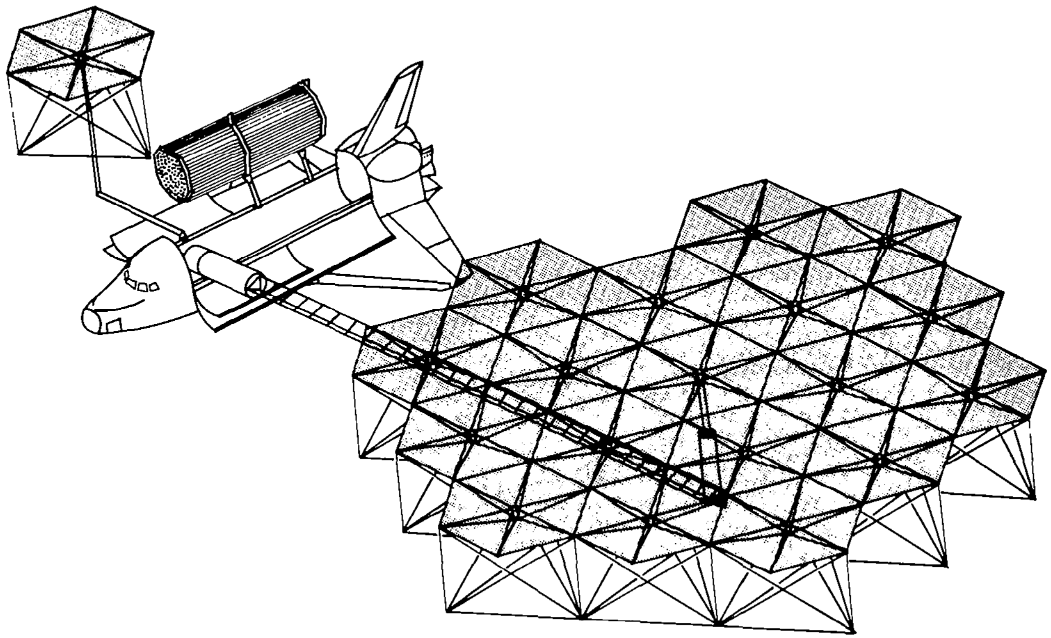
To produce large reflector apertures (> 300 m in diameter) assembly methods which use multiple shuttle flights to supply parts for a single reflector must be employed.

Assembly scenario 4 (shown in Figure 59) uses a free flying satellite as an assembly platform for the reflector. The assembly satellite consists of a multi-mission satellite body with an articulated reflector support attached to the top, the support for the extendable boom which in turn supports the solar arrays and a module installation arm. The initial shuttle flight deploys the satellite and delivers what modules can be carried in the remaining cargo bay volume. The Orbiter achieves a synchronized close formation to the satellite and deploys the cannister package. The modules are removed from the cannister and deployed by the RMS. They are then transferred to the installation arm of the satellite for attachment to the reflector.

The articulated arm rotates and tilts the reflector to align the next module installation position with the extendable arm. This arm is retracted until the new module is correctly positioned, and the module is then attached by extending the module support arm. After the module

METHOD

USE RMS AND AN ARTICULATED ASSEMBLY BOOM



PHILOSOPHY

THE RMS REMOVES EACH MODULE, DEPLOYS IT, AND ATTACHES IT TO THE ASSEMBLY. THE ARTICULATED BOOM POSITIONS THE REFLECTOR TO RECEIVE EACH NEW MODULE

Figure 58. Modular Antenna Assembly Scenario.

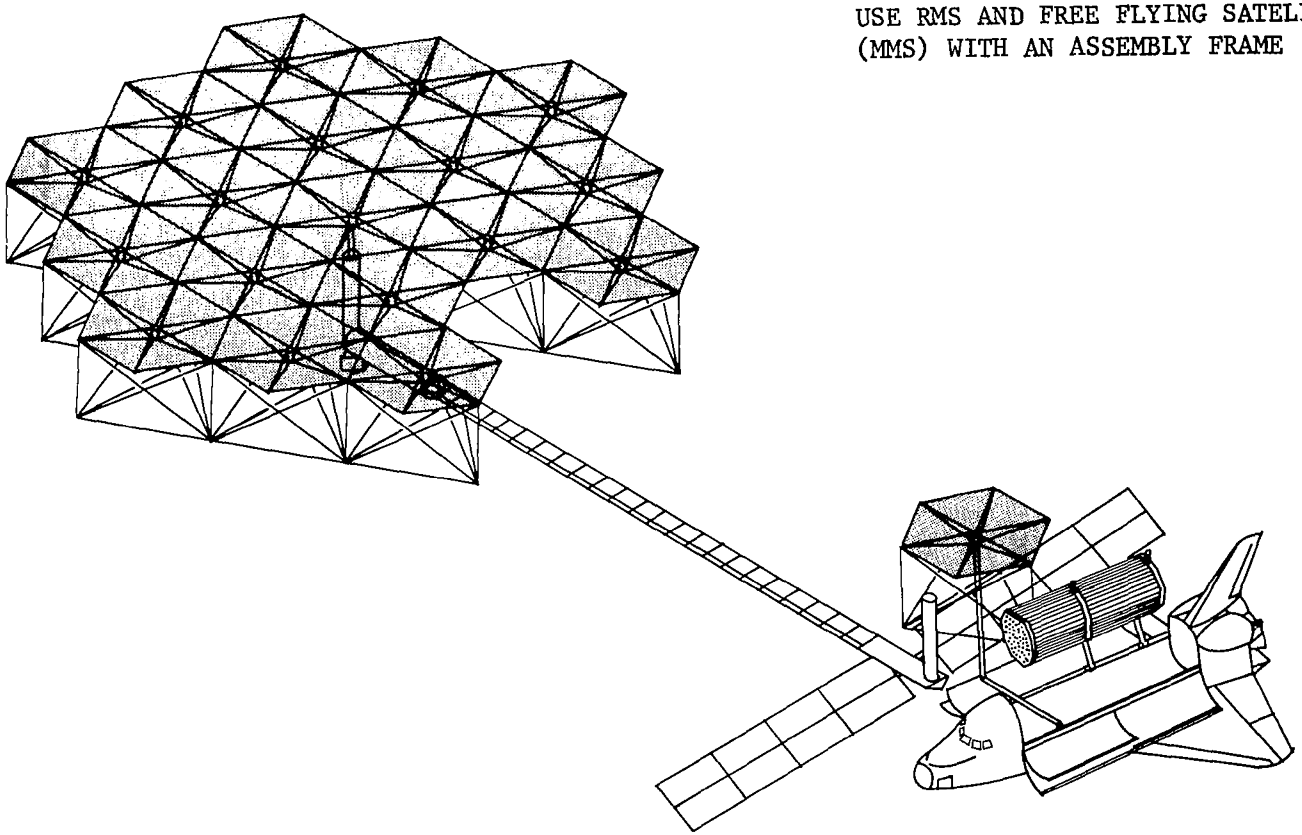


Figure 59. Modular Antenna Assembly Scenario.

is attached the module support arm is retracted to clear the module backup structure, and the arm is extended to receive another module from the Shuttle. When the reflector is complete, a feed assembly can be attached to the module support beam which then extends to become the vertical portion of the feed support tower.

The primary difficulty in this assembly is the interactive control of two independent spacecraft during the time when the module is being held by both the shuttle RMS arm and the satellite module support boom. The problems involved when two independently controlled spacecraft are in contact have been documented since the Gemini Program. An alternative solution to the transfer problem would be for an MMU equipped astronaut to transfer the modules either to the support boom, or to install them directly onto the reflector assembly, using the satellite's extendable boom solely as a support for the feed tower.

Rather than transferring modules from the Shuttle Orbiter to the assembly satellite one by one, the entire cannister of modules could be moved to the satellite, and deployed and installed by a manipulator arm on the satellite, as shown in Figure 60. The Shuttle Orbiter then would be used as a transport vehicle and control station for the servo-mechanisms aboard the assembly satellite which would remove the modules from the storage cannister, deploy them, and install them. Again in this scenario, MMV equipped astronauts could remove the deployed modules from the manipulator arm, position them, and attach them to the assembly. The size of these reflectors is limited only by the number of STS launches that can be dedicated to their construction. Table VI summarizes the assembly techniques discussed in this section along with their advantages, disadvantages, and areas of technological development required for their fulfillment.

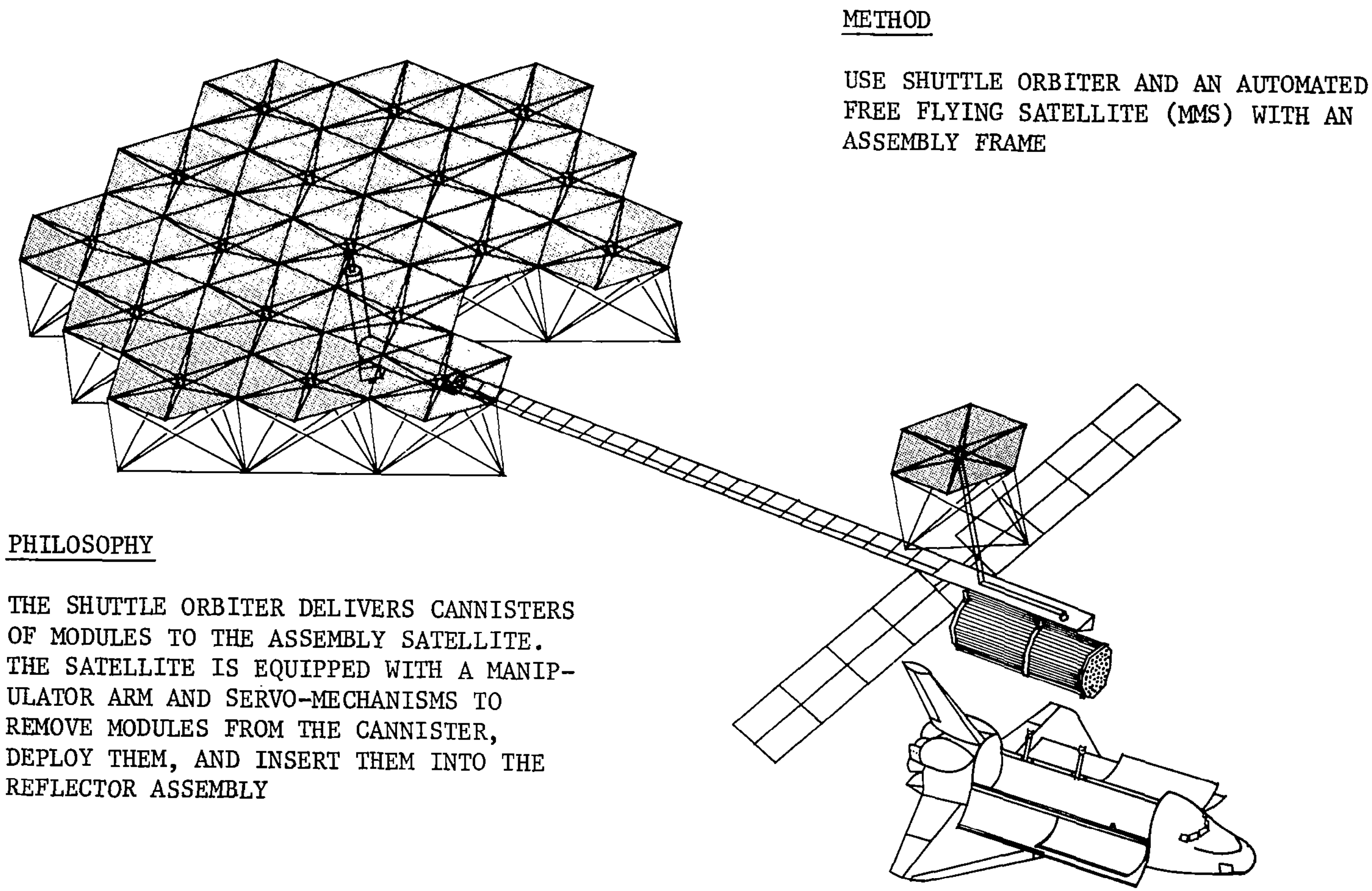


Figure 60. Modular Antenna Assembly Scenario.

TABLE VI REFLECTOR ASSEMBLY TECHNIQUES

METHOD	ADVANTAGES	DISADVANTAGES	NEW TECHNOLOGY REQUIRED
1. Assembly By 2 RMS's	o Least technology required	o Limited to ≈ 73 Meters by reach of RMS arms o Potential damage to modules by Orbiter attitude control	o Method for offset module contour determination o Development of storage cannister
2. Assembly Using Astronaut, RMS, and Boom	o Allows larger size reflectors than method 1 without added complexity of active assembly frames	o Potential damage to modules by Orbiter attitude control o Possible Orbiter attitude control effects due to variation in moment of inertia o Size limited to one shuttle launch capability (≈ 310 Meters Diameter) o Man required to free fly	o Method for offset module contour determination o Development of storage cannister o Safety aspects of free flying astronaut o Development of boom
3. Assembly By RMS and Articulated Boom Fixture	o EVA not required	o Potential damage to modules by Orbiter attitude control o Possible Orbiter attitude control effects due to variation of moment of inertia o Size limited to one shuttle launch capability (≈ 310 Meters Diameter)	o Method for offset module contour determination o Development of storage cannister o Development of Boom o Development of boom articulation servos
4. Assembly by Free Flying Satellite	o No site limit o Self contained power and attitude control	o Control fuel for flying formation for extended periods o Transfer of module between two independent spacecraft o Automated assembly servo systems required	o Method for offset module contour determination o Development of storage cannister o Development of boom o Development of boom articulation servos o Method of slaving attitude control of one spacecraft to another
5. Assembly by Free Flying Automated Satellite	o No size limit o Self contained power and attitude control o No dual spacecraft control problems	o Control of automation sequence of deployment and insertion of modules	o Method for offset module contour determination o Development of storage container o Development of boom o Development of boom articulation servos o Development of automation sequencing, control

4.0 CONCLUSIONS

4.1 Modular Antenna Feasibility

The kinematic studies and Engineering Demonstration Model developed during this study have fully verified the deployment kinematics, stowing philosophy, and deployment sequencing for large deployable antenna modules. These studies have established that such modules can be stowed in packages as small as 25 cm in diameter, using 1.27 cm diameter structural tubes. Mesh attachment methods compatible with full scale modules have been devised. Parametric studies of large modular reflectors using 1.27 cm diameter struts as structural elements have established size, mass and aperture frequency capabilities for these assemblies. Specific mission requirements should however be reviewed to verify tube sizing for each application. Preliminary studies have been made devising means of delivering modules to orbit, and once there, of assembling the modules into complete modular antenna reflectors. The basic feasibility of creating mass efficient modules, erectable into large structures in space has been established.

4.2 Recommendations for Further Study

The current study has established the feasibility of constructing modular elements for assembly into large structures. The module configuration used for this study maximize both the individual module diameter and backup structure depth in its stowed package. However, the kinematic requirement for folding the cross braces does complicate control of the module deployment and force the use of a fairly complex joint at the cross brace fold joint. For applications in which the depth of the backup structure can be reduced, simpler kinematic models can be constructed which use single piece cross braces.

Two candidate configurations for further study are shown in Figures 61 and 62. The first configuration uses cross braces which are pivoted at the mid-point. Therefore, when stowed, the cross braces scissors closed forcing the bottom struts to fold, allowing the deployment motion to be controlled entirely by the central jackscrew. The size limiting element for this configuration would be the length of the cross brace. Assuming a minimum structural depth of one half the module diameter, the cross brace length would be equal to the module diameter. Thus the maximum module size packageable in the Shuttle Orbiter is approximately 14 m. Several modules could possibly be ganged together, however, to deploy as a single unit.

The module shown in Figure 62 rearranges the cross braces into a drum shaped configuration. These cross arms fold inward parallel to the stowed package centerline as the radial arms stow, forcing the lower arms to fold. This configuration also eliminates the kinematic need for the deployment cable. The lower ends of the cross braces can be released sequentially for deployment. As in the previous configuration, the length of the cross braces can be varied to provide desired structural depth. Again assuming that a reasonable minimum structure of depth is one half the diameter, the cross brace elements would be approximately 1.32 times the module radius, thus limiting the modules transported in the Orbiter to approximately 21 meters in diameter. If even less structural depth were required these modules could approach 28 m diameter as a limit for zero structural depth. The precise kinematics of these module styles should be investigated to provide a full family of module configurations which would be compatible with a wide variety of potential antenna reflector applications.

The second area of investigation which should be pursued is refinement of the process of assembling many modular elements into single structures. This study would involve full detail design of module to module joints and fabrication of seven modules, which would allow operational

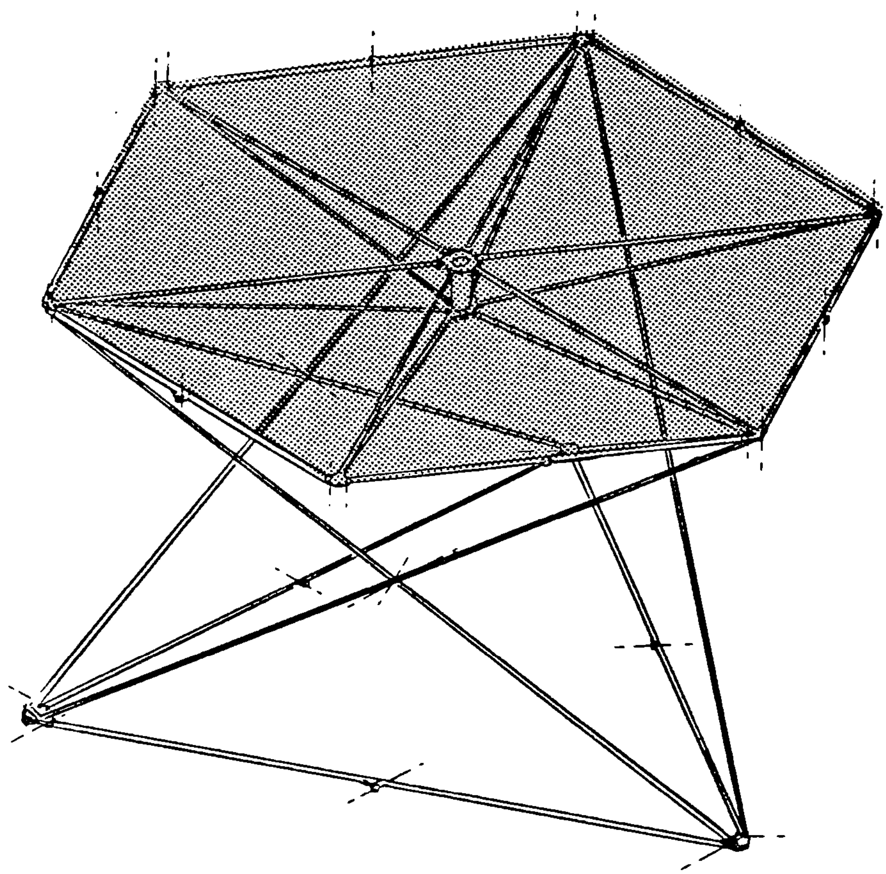


Figure 61. Alternate Module Configuration (Pivoted Cross Braces).

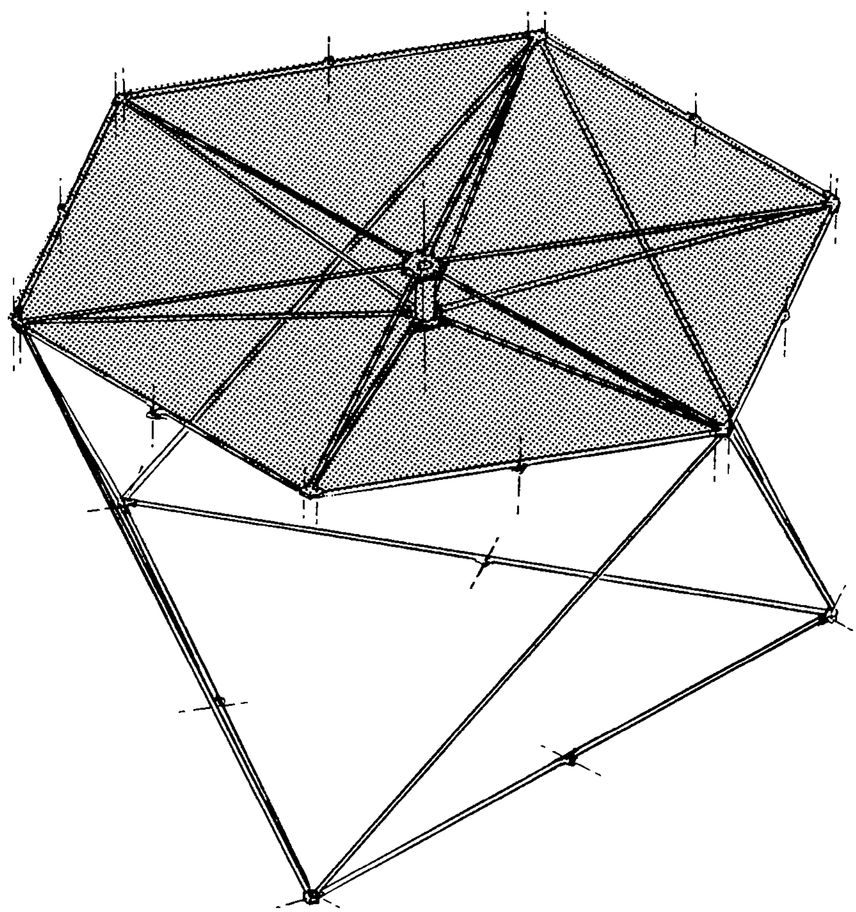


Figure 62. Alternate Module Configuration (Drum Style Cross Braces).

testing of both the module to module joining process and the replacement of one module either at the edge of or in the center of a reflector assembly. By assemblying seven modules, one center module and six surrounding modules, the general problem of structural assembly in either 1g or at neutral bouyancy can be evaluated, and realistic estimates of required assembly time can be obtained. Successful completion of the process would demonstrate the feasibility of structural assembly without support stands.

A third area of extended research would investigate increasing the effective size and/or operational frequency limit of each deployable module. The module size limits can be extended by developing the kinematics associated with deploying several modules simultaneously. This approach would allow deployment of sets of up to seven modules at once, thus decreasing the number of deployed modular elements required to construct a given reflector by a factor of seven, and reducing the orbital assembly time accordingly. The operational frequency can be increased by reducing the effective RMS surface error. Two approaches to this problem are to use a thin, flexible membrane with double curvature in place of the mesh surface, or to install separate rigid surface panels onto the erected modular subsurface. Such techniques, if successful, could extend the operational frequency into the millimeter wavelength range.

APPENDIX A

MODULAR ANTENNA PERFORMANCE STUDIES

```
NO OF MODULES ACROSS CORNERS=            5
MODULE DIAMETER ACROSS CORNERS=     28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=         88.61052 METERS
REFLECTOR PHYSICAL DIAMETER=      116.62178 METERS
REFLECTOR ELECTRICAL DIAMETER=    118.14736 METERS
SURFACE APPROXIMATION ERROR=       26.3193736 MM
```

```
NO OF MODULES ACROSS CORNERS=            9
MODULE DIAMETER ACROSS CORNERS=     28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        157.37147 METERS
REFLECTOR PHYSICAL DIAMETER=      207.11920 METERS
REFLECTOR ELECTRICAL DIAMETER=    209.82862 METERS
SURFACE APPROXIMATION ERROR=       14.8052589 MM
```

```
NO OF MODULES ACROSS CORNERS=           13
MODULE DIAMETER ACROSS CORNERS=     28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        226.13242 METERS
REFLECTOR PHYSICAL DIAMETER=      297.61663 METERS
REFLECTOR ELECTRICAL DIAMETER=    301.50989 METERS
SURFACE APPROXIMATION ERROR=       10.3009963 MM
```

```
NO OF MODULES ACROSS CORNERS=           17
MODULE DIAMETER ACROSS CORNERS=     28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        294.89336 METERS
REFLECTOR PHYSICAL DIAMETER=      388.11405 METERS
REFLECTOR ELECTRICAL DIAMETER=    393.19115 METERS
SURFACE APPROXIMATION ERROR=        7.8983905 MM
```

```
NO OF MODULES ACROSS CORNERS=           21
MODULE DIAMETER ACROSS CORNERS=     28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        363.65431 METERS
REFLECTOR PHYSICAL DIAMETER=      478.61147 METERS
REFLECTOR ELECTRICAL DIAMETER=    484.87241 METERS
SURFACE APPROXIMATION ERROR=        6.4046608 MM
```

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NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       432.41526 METERS
REFLECTOR PHYSICAL DIAMETER=     569.10889 METERS
REFLECTOR ELECTRICAL DIAMETER=   576.55367 METERS
SURFACE APPROXIMATION ERROR=       5.3860871 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       501.17620 METERS
REFLECTOR PHYSICAL DIAMETER=     659.60632 METERS
REFLECTOR ELECTRICAL DIAMETER=   668.23493 METERS
SURFACE APPROXIMATION ERROR=       4.6470513 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       569.93714 METERS
REFLECTOR PHYSICAL DIAMETER=     750.10374 METERS
REFLECTOR ELECTRICAL DIAMETER=   759.91619 METERS
SURFACE APPROXIMATION ERROR=       4.0863606 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       638.69810 METERS
REFLECTOR PHYSICAL DIAMETER=     840.60117 METERS
REFLECTOR ELECTRICAL DIAMETER=   851.59746 METERS
SURFACE APPROXIMATION ERROR=       3.6464064 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       707.45904 METERS
REFLECTOR PHYSICAL DIAMETER=     931.09859 METERS
REFLECTOR ELECTRICAL DIAMETER=   943.27872 METERS
SURFACE APPROXIMATION ERROR=       3.2919806 MM
```

```
NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        776.21999 METERS
REFLECTOR PHYSICAL DIAMETER=     1021.59602 METERS
REFLECTOR ELECTRICAL DIAMETER= 1034.95999 METERS
SURFACE APPROXIMATION ERROR=      3.0003515 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        844.98093 METERS
REFLECTOR PHYSICAL DIAMETER=     1112.09343 METERS
REFLECTOR ELECTRICAL DIAMETER= 1126.64124 METERS
SURFACE APPROXIMATION ERROR=      2.7561880 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        913.74187 METERS
REFLECTOR PHYSICAL DIAMETER=     1202.59085 METERS
REFLECTOR ELECTRICAL DIAMETER= 1218.32249 METERS
SURFACE APPROXIMATION ERROR=      2.5487736 MM


NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        982.50282 METERS
REFLECTOR PHYSICAL DIAMETER=     1293.08827 METERS
REFLECTOR ELECTRICAL DIAMETER= 1310.00375 METERS
SURFACE APPROXIMATION ERROR=      2.3703923 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=       1051.26376 METERS
REFLECTOR PHYSICAL DIAMETER=     1383.58569 METERS
REFLECTOR ELECTRICAL DIAMETER= 1401.68501 METERS
SURFACE APPROXIMATION ERROR=      2.2153468 MM
```

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NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       1120.02473 METERS
REFLECTOR PHYSICAL DIAMETER=     1474.08313 METERS
REFLECTOR ELECTRICAL DIAMETER=  1493.36630 METERS
SURFACE APPROXIMATION ERROR=       2.0793390 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=         69.62255 METERS
REFLECTOR PHYSICAL DIAMETER=       91.63140 METERS
REFLECTOR ELECTRICAL DIAMETER=    92.83007 METERS
SURFACE APPROXIMATION ERROR=      20.6795080 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=        123.64901 METERS
REFLECTOR PHYSICAL DIAMETER=      162.73652 METERS
REFLECTOR ELECTRICAL DIAMETER=   164.86535 METERS
SURFACE APPROXIMATION ERROR=      11.6327033 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=        177.67547 METERS
REFLECTOR PHYSICAL DIAMETER=      233.84163 METERS
REFLECTOR ELECTRICAL DIAMETER=   236.90063 METERS
SURFACE APPROXIMATION ERROR=       8.0936400 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=        231.70193 METERS
REFLECTOR PHYSICAL DIAMETER=      304.94675 METERS
REFLECTOR ELECTRICAL DIAMETER=   308.93590 METERS
SURFACE APPROXIMATION ERROR=       6.2058782 MM
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NO OF MODULES ACROSS CORNERS=         21
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       285.72838 METERS
REFLECTOR PHYSICAL DIAMETER=     376.05187 METERS
REFLECTOR ELECTRICAL DIAMETER=   380.97118 METERS
SURFACE APPROXIMATION ERROR=       5.0322335 MM


NO OF MODULES ACROSS CORNERS=         25
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       339.75484 METERS
REFLECTOR PHYSICAL DIAMETER=     447.15699 METERS
REFLECTOR ELECTRICAL DIAMETER=   453.00645 METERS
SURFACE APPROXIMATION ERROR=       4.2319256 MM


NO OF MODULES ACROSS CORNERS=         29
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       393.78130 METERS
REFLECTOR PHYSICAL DIAMETER=     518.26211 METERS
REFLECTOR ELECTRICAL DIAMETER=   525.04173 METERS
SURFACE APPROXIMATION ERROR=       3.6512547 MM


NO OF MODULES ACROSS CORNERS=         33
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       447.80776 METERS
REFLECTOR PHYSICAL DIAMETER=     589.36723 METERS
REFLECTOR ELECTRICAL DIAMETER=   597.07701 METERS
SURFACE APPROXIMATION ERROR=       3.2107119 MM


NO OF MODULES ACROSS CORNERS=         37
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       501.83422 METERS
REFLECTOR PHYSICAL DIAMETER=     660.47234 METERS
REFLECTOR ELECTRICAL DIAMETER=   669.11229 METERS
SURFACE APPROXIMATION ERROR=       2.8650336 MM
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NO OF MODULES ACROSS CORNERS=	41
MODULE DIAMETER ACROSS CORNERS=	22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=	0.75
FOCAL LENGTH OF REFLECTOR=	555.86068 METERS
REFLECTOR PHYSICAL DIAMETER=	731.57746 METERS
REFLECTOR ELECTRICAL DIAMETER=	741.14757 METERS
SURFACE APPROXIMATION ERROR=	2.5865561 MM

NO OF MODULES ACROSS CORNERS=	45
MODULE DIAMETER ACROSS CORNERS=	22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=	0.75
FOCAL LENGTH OF REFLECTOR=	609.88714 METERS
REFLECTOR PHYSICAL DIAMETER=	802.68258 METERS
REFLECTOR ELECTRICAL DIAMETER=	813.18285 METERS
SURFACE APPROXIMATION ERROR=	2.3574191 MM

NO OF MODULES ACROSS CORNERS=	49
MODULE DIAMETER ACROSS CORNERS=	22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=	0.75
FOCAL LENGTH OF REFLECTOR=	663.91358 METERS
REFLECTOR PHYSICAL DIAMETER=	873.78769 METERS
REFLECTOR ELECTRICAL DIAMETER=	885.21811 METERS
SURFACE APPROXIMATION ERROR=	2.1655763 MM

NO OF MODULES ACROSS CORNERS=	53
MODULE DIAMETER ACROSS CORNERS=	22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=	0.75
FOCAL LENGTH OF REFLECTOR=	717.94004 METERS
REFLECTOR PHYSICAL DIAMETER=	944.89281 METERS
REFLECTOR ELECTRICAL DIAMETER=	957.25339 METERS
SURFACE APPROXIMATION ERROR=	2.0026079 MM

NO OF MODULES ACROSS CORNERS=	57
MODULE DIAMETER ACROSS CORNERS=	22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=	0.75
FOCAL LENGTH OF REFLECTOR=	771.96650 METERS
REFLECTOR PHYSICAL DIAMETER=	1015.99793 METERS
REFLECTOR ELECTRICAL DIAMETER=	1029.28867 METERS
SURFACE APPROXIMATION ERROR=	1.8624511 MM

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NO OF MODULES ACROSS CORNERS=           17
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        168.51049 METERS
REFLECTOR PHYSICAL DIAMETER=      221.77946 METERS
REFLECTOR ELECTRICAL DIAMETER=    224.68065 METERS
SURFACE APPROXIMATION ERROR=        4.5133660 MM


NO OF MODULES ACROSS CORNERS=           21
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        207.80246 METERS
REFLECTOR PHYSICAL DIAMETER=      273.49227 METERS
REFLECTOR ELECTRICAL DIAMETER=    277.06995 METERS
SURFACE APPROXIMATION ERROR=        3.6598062 MM


NO OF MODULES ACROSS CORNERS=           25
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        247.09443 METERS
REFLECTOR PHYSICAL DIAMETER=      325.20508 METERS
REFLECTOR ELECTRICAL DIAMETER=    329.45924 METERS
SURFACE APPROXIMATION ERROR=        3.0777640 MM


NO OF MODULES ACROSS CORNERS=           29
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        286.38640 METERS
REFLECTOR PHYSICAL DIAMETER=      376.91790 METERS
REFLECTOR ELECTRICAL DIAMETER=    381.84853 METERS
SURFACE APPROXIMATION ERROR=        2.6554579 MM


NO OF MODULES ACROSS CORNERS=           33
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        325.67837 METERS
REFLECTOR PHYSICAL DIAMETER=      428.63071 METERS
REFLECTOR ELECTRICAL DIAMETER=    434.23782 METERS
SURFACE APPROXIMATION ERROR=        2.3350632 MM
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NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       825.99296 METERS
REFLECTOR PHYSICAL DIAMETER=    1087.10304 METERS
REFLECTOR ELECTRICAL DIAMETER= 1101.32394 METERS
SURFACE APPROXIMATION ERROR=      1.7406296 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       880.01943 METERS
REFLECTOR PHYSICAL DIAMETER=    1158.20818 METERS
REFLECTOR ELECTRICAL DIAMETER= 1173.35924 METERS
SURFACE APPROXIMATION ERROR=      1.6337664 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=        50.63458 METERS
REFLECTOR PHYSICAL DIAMETER=      66.64102 METERS
REFLECTOR ELECTRICAL DIAMETER=    67.51278 METERS
SURFACE APPROXIMATION ERROR=     15.0396421 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=        89.92655 METERS
REFLECTOR PHYSICAL DIAMETER=     118.35383 METERS
REFLECTOR ELECTRICAL DIAMETER=   119.90207 METERS
SURFACE APPROXIMATION ERROR=      8.4601479 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       129.21852 METERS
REFLECTOR PHYSICAL DIAMETER=     170.06664 METERS
REFLECTOR ELECTRICAL DIAMETER=   172.29136 METERS
SURFACE APPROXIMATION ERROR=      5.8862836 MM
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NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       364.97034 METERS
REFLECTOR PHYSICAL DIAMETER=     480.34352 METERS
REFLECTOR ELECTRICAL DIAMETER=  486.62712 METERS
SURFACE APPROXIMATION ERROR=      2.0836608 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       404.26231 METERS
REFLECTOR PHYSICAL DIAMETER=     532.05634 METERS
REFLECTOR ELECTRICAL DIAMETER=  539.01641 METERS
SURFACE APPROXIMATION ERROR=      1.8811317 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       443.55428 METERS
REFLECTOR PHYSICAL DIAMETER=     583.76915 METERS
REFLECTOR ELECTRICAL DIAMETER=  591.40571 METERS
SURFACE APPROXIMATION ERROR=      1.7144866 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       482.84624 METERS
REFLECTOR PHYSICAL DIAMETER=     635.48196 METERS
REFLECTOR ELECTRICAL DIAMETER=  643.79499 METERS
SURFACE APPROXIMATION ERROR=      1.5749646 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       522.13821 METERS
REFLECTOR PHYSICAL DIAMETER=     687.19477 METERS
REFLECTOR ELECTRICAL DIAMETER=  696.18429 METERS
SURFACE APPROXIMATION ERROR=      1.4564421 MM
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NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        561.43018 METERS
REFLECTOR PHYSICAL DIAMETER=      738.90759 METERS
REFLECTOR ELECTRICAL DIAMETER=    748.57358 METERS
SURFACE APPROXIMATION ERROR=       1.3545099 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        600.72216 METERS
REFLECTOR PHYSICAL DIAMETER=      790.62040 METERS
REFLECTOR ELECTRICAL DIAMETER=    800.96288 METERS
SURFACE APPROXIMATION ERROR=       1.2659124 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        640.01412 METERS
REFLECTOR PHYSICAL DIAMETER=      842.33321 METERS
REFLECTOR ELECTRICAL DIAMETER=    853.35217 METERS
SURFACE APPROXIMATION ERROR=       1.1881937 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=         31.64662 METERS
REFLECTOR PHYSICAL DIAMETER=       41.65064 METERS
REFLECTOR ELECTRICAL DIAMETER=     42.19549 METERS
SURFACE APPROXIMATION ERROR=       9.3997763 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=         56.20410 METERS
REFLECTOR PHYSICAL DIAMETER=       73.97114 METERS
REFLECTOR ELECTRICAL DIAMETER=     74.93879 METERS
SURFACE APPROXIMATION ERROR=       5.2875924 MM
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NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=        80.76158 METERS
REFLECTOR PHYSICAL DIAMETER=     106.29165 METERS
REFLECTOR ELECTRICAL DIAMETER=   107.68210 METERS
SURFACE APPROXIMATION ERROR=      3.6789273 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=       105.31906 METERS
REFLECTOR PHYSICAL DIAMETER=     138.61216 METERS
REFLECTOR ELECTRICAL DIAMETER=   140.42541 METERS
SURFACE APPROXIMATION ERROR=      2.8208538 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=       129.87654 METERS
REFLECTOR PHYSICAL DIAMETER=     170.93267 METERS
REFLECTOR ELECTRICAL DIAMETER=   173.16872 METERS
SURFACE APPROXIMATION ERROR=      2.2873789 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=       154.43402 METERS
REFLECTOR PHYSICAL DIAMETER=     203.25318 METERS
REFLECTOR ELECTRICAL DIAMETER=   205.91203 METERS
SURFACE APPROXIMATION ERROR=      1.9236025 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     0.75
FOCAL LENGTH OF REFLECTOR=       178.99150 METERS
REFLECTOR PHYSICAL DIAMETER=     235.57368 METERS
REFLECTOR ELECTRICAL DIAMETER=   238.65533 METERS
SURFACE APPROXIMATION ERROR=      1.6596612 MM
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NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       203.54898 METERS
REFLECTOR PHYSICAL DIAMETER=     267.89419 METERS
REFLECTOR ELECTRICAL DIAMETER=  271.39864 METERS
SURFACE APPROXIMATION ERROR=      1.4594145 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       228.10646 METERS
REFLECTOR PHYSICAL DIAMETER=     300.21470 METERS
REFLECTOR ELECTRICAL DIAMETER=  304.14195 METERS
SURFACE APPROXIMATION ERROR=      1.3022880 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       252.66394 METERS
REFLECTOR PHYSICAL DIAMETER=     332.53521 METERS
REFLECTOR ELECTRICAL DIAMETER=  336.88526 METERS
SURFACE APPROXIMATION ERROR=      1.1757073 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       277.22142 METERS
REFLECTOR PHYSICAL DIAMETER=     364.85572 METERS
REFLECTOR ELECTRICAL DIAMETER=  369.62857 METERS
SURFACE APPROXIMATION ERROR=      1.0715541 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       301.77890 METERS
REFLECTOR PHYSICAL DIAMETER=     397.17622 METERS
REFLECTOR ELECTRICAL DIAMETER=  402.37187 METERS
SURFACE APPROXIMATION ERROR=      0.9843529 MM
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NO OF MODULES ACROSS CORNERS=           53
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       326.33638 METERS
REFLECTOR PHYSICAL DIAMETER=     429.49673 METERS
REFLECTOR ELECTRICAL DIAMETER=   435.11518 METERS
SURFACE APPROXIMATION ERROR=       0.9102763 MM


NO OF MODULES ACROSS CORNERS=           57
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       350.89386 METERS
REFLECTOR PHYSICAL DIAMETER=     461.81724 METERS
REFLECTOR ELECTRICAL DIAMETER=   467.85849 METERS
SURFACE APPROXIMATION ERROR=       0.8465687 MM


NO OF MODULES ACROSS CORNERS=           61
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       375.45135 METERS
REFLECTOR PHYSICAL DIAMETER=     494.13775 METERS
REFLECTOR ELECTRICAL DIAMETER=   500.60180 METERS
SURFACE APPROXIMATION ERROR=       0.7911953 MM


NO OF MODULES ACROSS CORNERS=           65
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    0.75
FOCAL LENGTH OF REFLECTOR=       400.00883 METERS
REFLECTOR PHYSICAL DIAMETER=     526.45826 METERS
REFLECTOR ELECTRICAL DIAMETER=   533.34511 METERS
SURFACE APPROXIMATION ERROR=       0.7426211 MM


NO OF MODULES ACROSS CORNERS=            5
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       117.50216 METERS
REFLECTOR PHYSICAL DIAMETER
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NO OF MODULES ACROSS CORNERS=            5
MODULE DIAMETER ACROSS CORNERS=   29.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       117.50216 METERS
REFLECTOR PHYSICAL DIAMETER=     116.62178 METERS
REFLECTOR ELECTRICAL DIAMETER=   117.50216 METERS
SURFACE APPROXIMATION ERROR=      19.9793613 MM


NO OF MODULES ACROSS CORNERS=            9
MODULE DIAMETER ACROSS CORNERS=   29.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       208.68274 METERS
REFLECTOR PHYSICAL DIAMETER=     207.11920 METERS
REFLECTOR ELECTRICAL DIAMETER=   208.68274 METERS
SURFACE APPROXIMATION ERROR=      11.2438538 MM


NO OF MODULES ACROSS CORNERS=           13
MODULE DIAMETER ACROSS CORNERS=   29.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       299.86333 METERS
REFLECTOR PHYSICAL DIAMETER=     297.61663 METERS
REFLECTOR ELECTRICAL DIAMETER=   299.86333 METERS
SURFACE APPROXIMATION ERROR=       7.8239220 MM


NO OF MODULES ACROSS CORNERS=           17
MODULE DIAMETER ACROSS CORNERS=   29.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       391.04392 METERS
REFLECTOR PHYSICAL DIAMETER=     388.11405 METERS
REFLECTOR ELECTRICAL DIAMETER=   391.04392 METERS
SURFACE APPROXIMATION ERROR=       5.9993143 MM


NO OF MODULES ACROSS CORNERS=           21
MODULE DIAMETER ACROSS CORNERS=   29.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       482.22451 METERS
REFLECTOR PHYSICAL DIAMETER=     478.61147 METERS
REFLECTOR ELECTRICAL DIAMETER=   482.22451 METERS
SURFACE APPROXIMATION ERROR=       4.8648313 MM
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NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       573.40510 METERS
REFLECTOR PHYSICAL DIAMETER=     569.10999 METERS
REFLECTOR ELECTRICAL DIAMETER=  573.40510 METERS
SURFACE APPROXIMATION ERROR=      4.0911920 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       664.58569 METERS
REFLECTOR PHYSICAL DIAMETER=     659.60632 METERS
REFLECTOR ELECTRICAL DIAMETER=  664.58569 METERS
SURFACE APPROXIMATION ERROR=      3.5298556 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       755.76627 METERS
REFLECTOR PHYSICAL DIAMETER=     750.10374 METERS
REFLECTOR ELECTRICAL DIAMETER=  755.76627 METERS
SURFACE APPROXIMATION ERROR=      3.1039743 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       846.94687 METERS
REFLECTOR PHYSICAL DIAMETER=     840.60117 METERS
REFLECTOR ELECTRICAL DIAMETER=  846.94687 METERS
SURFACE APPROXIMATION ERROR=      2.7697965 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       938.12746 METERS
REFLECTOR PHYSICAL DIAMETER=     931.09859 METERS
REFLECTOR ELECTRICAL DIAMETER=  938.12746 METERS
SURFACE APPROXIMATION ERROR=      2.5005816 MM
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NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1029.30804 METERS
REFLECTOR PHYSICAL DIAMETER=    1021.59602 METERS
REFLECTOR ELECTRICAL DIAMETER= 1029.30804 METERS
SURFACE APPROXIMATION ERROR=      2.2790647 MM
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NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1120.48863 METERS
REFLECTOR PHYSICAL DIAMETER=    1112.09343 METERS
REFLECTOR ELECTRICAL DIAMETER= 1120.48863 METERS
SURFACE APPROXIMATION ERROR=      2.0936010 MM
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NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1211.66922 METERS
REFLECTOR PHYSICAL DIAMETER=    1202.59085 METERS
REFLECTOR ELECTRICAL DIAMETER= 1211.66922 METERS
SURFACE APPROXIMATION ERROR=      1.9360509 MM
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NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1302.84981 METERS
REFLECTOR PHYSICAL DIAMETER=    1293.08827 METERS
REFLECTOR ELECTRICAL DIAMETER= 1302.84981 METERS
SURFACE APPROXIMATION ERROR=      1.8005538 MM
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NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1394.03040 METERS
REFLECTOR PHYSICAL DIAMETER=    1383.58569 METERS
REFLECTOR ELECTRICAL DIAMETER= 1394.03040 METERS
SURFACE APPROXIMATION ERROR=      1.6827821 MM
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NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1485.21100 METERS
REFLECTOR PHYSICAL DIAMETER=    1474.08313 METERS
REFLECTOR ELECTRICAL DIAMETER= 1485.21100 METERS
SURFACE APPROXIMATION ERROR=      1.5794711 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=        92.32312 METERS
REFLECTOR PHYSICAL DIAMETER=      91.63140 METERS
REFLECTOR ELECTRICAL DIAMETER=    92.32312 METERS
SURFACE APPROXIMATION ERROR=     15.6980695 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       163.96501 METERS
REFLECTOR PHYSICAL DIAMETER=     162.73652 METERS
REFLECTOR ELECTRICAL DIAMETER=   163.96501 METERS
SURFACE APPROXIMATION ERROR=      8.8344567 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       235.60691 METERS
REFLECTOR PHYSICAL DIAMETER=     233.84163 METERS
REFLECTOR ELECTRICAL DIAMETER=   235.60691 METERS
SURFACE APPROXIMATION ERROR=      6.1473673 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       307.24879 METERS
REFLECTOR PHYSICAL DIAMETER=     304.94675 METERS
REFLECTOR ELECTRICAL DIAMETER=   307.24879 METERS
SURFACE APPROXIMATION ERROR=      4.7137470 MM
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NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        378.89069 METERS
REFLECTOR PHYSICAL DIAMETER=      376.05187 METERS
REFLECTOR ELECTRICAL DIAMETER=    378.89069 METERS
SURFACE APPROXIMATION ERROR=        3.8223675 MM
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NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        450.53258 METERS
REFLECTOR PHYSICAL DIAMETER=      447.15699 METERS
REFLECTOR ELECTRICAL DIAMETER=    450.53258 METERS
SURFACE APPROXIMATION ERROR=        3.2145080 MM
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NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        522.17447 METERS
REFLECTOR PHYSICAL DIAMETER=      518.26211 METERS
REFLECTOR ELECTRICAL DIAMETER=    522.17447 METERS
SURFACE APPROXIMATION ERROR=        2.7734580 MM
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NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        593.81636 METERS
REFLECTOR PHYSICAL DIAMETER=      589.36723 METERS
REFLECTOR ELECTRICAL DIAMETER=    593.81636 METERS
SURFACE APPROXIMATION ERROR=        2.4388370 MM
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NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        665.45825 METERS
REFLECTOR PHYSICAL DIAMETER=      660.47234 METERS
REFLECTOR ELECTRICAL DIAMETER=    665.45825 METERS
SURFACE APPROXIMATION ERROR=        2.1762687 MM
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NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       737.10014 METERS
REFLECTOR PHYSICAL DIAMETER=     731.57746 METERS
REFLECTOR ELECTRICAL DIAMETER=  737.10014 METERS
SURFACE APPROXIMATION ERROR=      1.9647427 MM
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NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       808.74203 METERS
REFLECTOR PHYSICAL DIAMETER=     802.68258 METERS
REFLECTOR ELECTRICAL DIAMETER=  808.74203 METERS
SURFACE APPROXIMATION ERROR=      1.7906937 MM
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NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       880.38392 METERS
REFLECTOR PHYSICAL DIAMETER=     873.78769 METERS
REFLECTOR ELECTRICAL DIAMETER=  880.38392 METERS
SURFACE APPROXIMATION ERROR=      1.6449722 MM
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NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       952.02581 METERS
REFLECTOR PHYSICAL DIAMETER=     944.89281 METERS
REFLECTOR ELECTRICAL DIAMETER=  952.02581 METERS
SURFACE APPROXIMATION ERROR=      1.5211829 MM
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NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=      1023.66771 METERS
REFLECTOR PHYSICAL DIAMETER=    1015.99793 METERS
REFLECTOR ELECTRICAL DIAMETER= 1023.66771 METERS
SURFACE APPROXIMATION ERROR=      1.4147208 MM
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NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=       1095.30959 METERS
REFLECTOR PHYSICAL DIAMETER=     1087.10304 METERS
REFLECTOR ELECTRICAL DIAMETER=   1095.30959 METERS
SURFACE APPROXIMATION ERROR=       1.3221859 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=       1166.95149 METERS
REFLECTOR PHYSICAL DIAMETER=     1158.20818 METERS
REFLECTOR ELECTRICAL DIAMETER=   1166.95149 METERS
SURFACE APPROXIMATION ERROR=       1.2410130 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=         67.14409 METERS
REFLECTOR PHYSICAL DIAMETER=       66.64102 METERS
REFLECTOR ELECTRICAL DIAMETER=     67.14409 METERS
SURFACE APPROXIMATION ERROR=      11.4167779 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        119.24728 METERS
REFLECTOR PHYSICAL DIAMETER=      118.35383 METERS
REFLECTOR ELECTRICAL DIAMETER=    119.24728 METERS
SURFACE APPROXIMATION ERROR=       6.4250593 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        171.35048 METERS
REFLECTOR PHYSICAL DIAMETER=      170.06664 METERS
REFLECTOR ELECTRICAL DIAMETER=    171.35048 METERS
SURFACE APPROXIMATION ERROR=       4.4708126 MM
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NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       223.45367 METERS
REFLECTOR PHYSICAL DIAMETER=     221.77946 METERS
REFLECTOR ELECTRICAL DIAMETER=   223.45367 METERS
SURFACE APPROXIMATION ERROR=       3.4281796 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       275.55686 METERS
REFLECTOR PHYSICAL DIAMETER=     273.49227 METERS
REFLECTOR ELECTRICAL DIAMETER=   275.55686 METERS
SURFACE APPROXIMATION ERROR=       2.7799036 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       327.66006 METERS
REFLECTOR PHYSICAL DIAMETER=     325.20508 METERS
REFLECTOR ELECTRICAL DIAMETER=   327.66006 METERS
SURFACE APPROXIMATION ERROR=       2.3378240 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       379.76325 METERS
REFLECTOR PHYSICAL DIAMETER=     376.91790 METERS
REFLECTOR ELECTRICAL DIAMETER=   379.76325 METERS
SURFACE APPROXIMATION ERROR=       2.0170603 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       431.86644 METERS
REFLECTOR PHYSICAL DIAMETER=     428.63071 METERS
REFLECTOR ELECTRICAL DIAMETER=   431.86644 METERS
SURFACE APPROXIMATION ERROR=       1.7736996 MM
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NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       483.96964 METERS
REFLECTOR PHYSICAL DIAMETER=     480.34352 METERS
REFLECTOR ELECTRICAL DIAMETER=   483.96964 METERS
SURFACE APPROXIMATION ERROR=       1.5827409 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       536.07283 METERS
REFLECTOR PHYSICAL DIAMETER=     532.05634 METERS
REFLECTOR ELECTRICAL DIAMETER=   536.07283 METERS
SURFACE APPROXIMATION ERROR=       1.4289038 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       588.17603 METERS
REFLECTOR PHYSICAL DIAMETER=     583.76915 METERS
REFLECTOR ELECTRICAL DIAMETER=   588.17603 METERS
SURFACE APPROXIMATION ERROR=       1.3023227 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       640.27921 METERS
REFLECTOR PHYSICAL DIAMETER=     635.48196 METERS
REFLECTOR ELECTRICAL DIAMETER=   640.27921 METERS
SURFACE APPROXIMATION ERROR=       1.1963434 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       692.38241 METERS
REFLECTOR PHYSICAL DIAMETER=     687.19477 METERS
REFLECTOR ELECTRICAL DIAMETER=   692.38241 METERS
SURFACE APPROXIMATION ERROR=       1.1063148 MM
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NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       744.48560 METERS
REFLECTOR PHYSICAL DIAMETER=     738.90759 METERS
REFLECTOR ELECTRICAL DIAMETER=   744.48560 METERS
SURFACE APPROXIMATION ERROR=      1.0288879 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       796.58880 METERS
REFLECTOR PHYSICAL DIAMETER=     790.62040 METERS
REFLECTOR ELECTRICAL DIAMETER=   796.58880 METERS
SURFACE APPROXIMATION ERROR=      0.9615898 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       848.69199 METERS
REFLECTOR PHYSICAL DIAMETER=     842.33321 METERS
REFLECTOR ELECTRICAL DIAMETER=   848.69199 METERS
SURFACE APPROXIMATION ERROR=      0.9025549 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=        41.96506 METERS
REFLECTOR PHYSICAL DIAMETER=      41.65064 METERS
REFLECTOR ELECTRICAL DIAMETER=    41.96506 METERS
SURFACE APPROXIMATION ERROR=      7.1354862 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=        74.52955 METERS
REFLECTOR PHYSICAL DIAMETER=      73.97114 METERS
REFLECTOR ELECTRICAL DIAMETER=    74.52955 METERS
SURFACE APPROXIMATION ERROR=      4.0156621 MM
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NO OF MODULES ACROSS CORNERS=           13
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       107.09405 METERS
REFLECTOR PHYSICAL DIAMETER=     106.29165 METERS
REFLECTOR ELECTRICAL DIAMETER=  107.09405 METERS
SURFACE APPROXIMATION ERROR=      2.7942578 MM


NO OF MODULES ACROSS CORNERS=           17
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       139.65854 METERS
REFLECTOR PHYSICAL DIAMETER=     138.61216 METERS
REFLECTOR ELECTRICAL DIAMETER=  139.65854 METERS
SURFACE APPROXIMATION ERROR=      2.1426122 MM


NO OF MODULES ACROSS CORNERS=           21
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       172.22304 METERS
REFLECTOR PHYSICAL DIAMETER=     170.93267 METERS
REFLECTOR ELECTRICAL DIAMETER=  172.22304 METERS
SURFACE APPROXIMATION ERROR=      1.7374398 MM


NO OF MODULES ACROSS CORNERS=           25
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       204.78753 METERS
REFLECTOR PHYSICAL DIAMETER=     203.25318 METERS
REFLECTOR ELECTRICAL DIAMETER=  204.78753 METERS
SURFACE APPROXIMATION ERROR=      1.4611400 MM


NO OF MODULES ACROSS CORNERS=           29
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.00
FOCAL LENGTH OF REFLECTOR=       237.35203 METERS
REFLECTOR PHYSICAL DIAMETER=     235.57368 METERS
REFLECTOR ELECTRICAL DIAMETER=  237.35203 METERS
SURFACE APPROXIMATION ERROR=      1.2606627 MM
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NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        269.91653 METERS
REFLECTOR PHYSICAL DIAMETER=      267.89419 METERS
REFLECTOR ELECTRICAL DIAMETER=    269.91653 METERS
SURFACE APPROXIMATION ERROR=        1.1085623 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        302.48103 METERS
REFLECTOR PHYSICAL DIAMETER=      300.21470 METERS
REFLECTOR ELECTRICAL DIAMETER=    302.48103 METERS
SURFACE APPROXIMATION ERROR=        0.9892130 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        335.04552 METERS
REFLECTOR PHYSICAL DIAMETER=      332.53521 METERS
REFLECTOR ELECTRICAL DIAMETER=    335.04552 METERS
SURFACE APPROXIMATION ERROR=        0.8930649 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        367.61002 METERS
REFLECTOR PHYSICAL DIAMETER=      364.85572 METERS
REFLECTOR ELECTRICAL DIAMETER=    367.61002 METERS
SURFACE APPROXIMATION ERROR=        0.8139517 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        400.17451 METERS
REFLECTOR PHYSICAL DIAMETER=      397.17622 METERS
REFLECTOR ELECTRICAL DIAMETER=    400.17451 METERS
SURFACE APPROXIMATION ERROR=        0.7477146 MM
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NO OF MODULES ACROSS CORNERS=            53
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        432.73901 METERS
REFLECTOR PHYSICAL DIAMETER=      429.49673 METERS
REFLECTOR ELECTRICAL DIAMETER=    432.73901 METERS
SURFACE APPROXIMATION ERROR=        0.6914468 MM


NO OF MODULES ACROSS CORNERS=            57
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        465.30350 METERS
REFLECTOR PHYSICAL DIAMETER=      461.81724 METERS
REFLECTOR ELECTRICAL DIAMETER=    465.30350 METERS
SURFACE APPROXIMATION ERROR=        0.6430549 MM


NO OF MODULES ACROSS CORNERS=            61
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        497.86800 METERS
REFLECTOR PHYSICAL DIAMETER=      494.13775 METERS
REFLECTOR ELECTRICAL DIAMETER=    497.86800 METERS
SURFACE APPROXIMATION ERROR=        0.6009936 MM


NO OF MODULES ACROSS CORNERS=            65
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.00
FOCAL LENGTH OF REFLECTOR=        530.43250 METERS
REFLECTOR PHYSICAL DIAMETER=      526.45826 METERS
REFLECTOR ELECTRICAL DIAMETER=    530.43250 METERS
SURFACE APPROXIMATION ERROR=        0.5640968 MM
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NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       146.49014 METERS
REFLECTOR PHYSICAL DIAMETER=     116.62178 METERS
REFLECTOR ELECTRICAL DIAMETER=   117.19212 METERS
SURFACE APPROXIMATION ERROR=      16.0719399 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       260.16515 METERS
REFLECTOR PHYSICAL DIAMETER=     207.11920 METERS
REFLECTOR ELECTRICAL DIAMETER=   208.13212 METERS
SURFACE APPROXIMATION ERROR=       9.0466228 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       373.84015 METERS
REFLECTOR PHYSICAL DIAMETER=     297.61663 METERS
REFLECTOR ELECTRICAL DIAMETER=   299.07212 METERS
SURFACE APPROXIMATION ERROR=       6.2952936 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       487.51514 METERS
REFLECTOR PHYSICAL DIAMETER=     388.11405 METERS
REFLECTOR ELECTRICAL DIAMETER=   390.01212 METERS
SURFACE APPROXIMATION ERROR=       4.8272619 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       601.19014 METERS
REFLECTOR PHYSICAL DIAMETER=     478.61147 METERS
REFLECTOR ELECTRICAL DIAMETER=   480.95211 METERS
SURFACE APPROXIMATION ERROR=       3.9144506 MM
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NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=       714.86514 METERS
REFLECTOR PHYSICAL DIAMETER=     569.10889 METERS
REFLECTOR ELECTRICAL DIAMETER=   571.89211 METERS
SURFACE APPROXIMATION ERROR=       3.2919635 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=       828.54015 METERS
REFLECTOR PHYSICAL DIAMETER=     659.60632 METERS
REFLECTOR ELECTRICAL DIAMETER=   662.83212 METERS
SURFACE APPROXIMATION ERROR=       2.8402947 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=       942.21514 METERS
REFLECTOR PHYSICAL DIAMETER=     750.10374 METERS
REFLECTOR ELECTRICAL DIAMETER=   753.77211 METERS
SURFACE APPROXIMATION ERROR=       2.4976147 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=      1055.89015 METERS
REFLECTOR PHYSICAL DIAMETER=     840.60117 METERS
REFLECTOR ELECTRICAL DIAMETER=   844.71212 METERS
SURFACE APPROXIMATION ERROR=       2.2287214 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=      1169.56514 METERS
REFLECTOR PHYSICAL DIAMETER=     931.09859 METERS
REFLECTOR ELECTRICAL DIAMETER=   935.65211 METERS
SURFACE APPROXIMATION ERROR=       2.0120992 MM
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NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       1283.24014 METERS
REFLECTOR PHYSICAL DIAMETER=     1021.59602 METERS
REFLECTOR ELECTRICAL DIAMETER=  1026.59212 METERS
SURFACE APPROXIMATION ERROR=       1.8338564 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       1396.91513 METERS
REFLECTOR PHYSICAL DIAMETER=     1112.09343 METERS
REFLECTOR ELECTRICAL DIAMETER=  1117.53210 METERS
SURFACE APPROXIMATION ERROR=       1.6846234 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       1510.59013 METERS
REFLECTOR PHYSICAL DIAMETER=     1202.59085 METERS
REFLECTOR ELECTRICAL DIAMETER=  1208.47211 METERS
SURFACE APPROXIMATION ERROR=       1.5578509 MM


NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       1624.26514 METERS
REFLECTOR PHYSICAL DIAMETER=     1293.08827 METERS
REFLECTOR ELECTRICAL DIAMETER=  1299.41211 METERS
SURFACE APPROXIMATION ERROR=       1.4488231 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       1737.94014 METERS
REFLECTOR PHYSICAL DIAMETER=     1383.58569 METERS
REFLECTOR ELECTRICAL DIAMETER=  1390.35211 METERS
SURFACE APPROXIMATION ERROR=       1.3540580 MM
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NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=       1851.61514 METERS
REFLECTOR PHYSICAL DIAMETER=     1474.08313 METERS
REFLECTOR ELECTRICAL DIAMETER=  1481.29211 METERS
SURFACE APPROXIMATION ERROR=       1.2709287 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        115.09940 METERS
REFLECTOR PHYSICAL DIAMETER=       91.63140 METERS
REFLECTOR ELECTRICAL DIAMETER=     92.07952 METERS
SURFACE APPROXIMATION ERROR=      12.6279528 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        204.41547 METERS
REFLECTOR PHYSICAL DIAMETER=      162.73652 METERS
REFLECTOR ELECTRICAL DIAMETER=    163.53238 METERS
SURFACE APPROXIMATION ERROR=       7.1080608 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        293.73154 METERS
REFLECTOR PHYSICAL DIAMETER=      233.84163 METERS
REFLECTOR ELECTRICAL DIAMETER=    234.98524 METERS
SURFACE APPROXIMATION ERROR=       4.9463022 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=    22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        383.04762 METERS
REFLECTOR PHYSICAL DIAMETER=      304.94675 METERS
REFLECTOR ELECTRICAL DIAMETER=    306.43809 METERS
SURFACE APPROXIMATION ERROR=       3.7928486 MM
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NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       472.36368 METERS
REFLECTOR PHYSICAL DIAMETER=     376.05187 METERS
REFLECTOR ELECTRICAL DIAMETER=   377.89095 METERS
SURFACE APPROXIMATION ERROR=       3.0756398 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       561.67976 METERS
REFLECTOR PHYSICAL DIAMETER=     447.15699 METERS
REFLECTOR ELECTRICAL DIAMETER=   449.34380 METERS
SURFACE APPROXIMATION ERROR=       2.5865428 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       650.99583 METERS
REFLECTOR PHYSICAL DIAMETER=     518.26211 METERS
REFLECTOR ELECTRICAL DIAMETER=   520.79666 METERS
SURFACE APPROXIMATION ERROR=       2.2316601 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       740.31190 METERS
REFLECTOR PHYSICAL DIAMETER=     589.36723 METERS
REFLECTOR ELECTRICAL DIAMETER=   592.24952 METERS
SURFACE APPROXIMATION ERROR=       1.9624115 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       829.62798 METERS
REFLECTOR PHYSICAL DIAMETER=     660.47234 METERS
REFLECTOR ELECTRICAL DIAMETER=   663.70238 METERS
SURFACE APPROXIMATION ERROR=       1.7511382 MM
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NO OF MODULES ACROSS CORNERS=           41
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       918.94405 METERS
REFLECTOR PHYSICAL DIAMETER=     731.57746 METERS
REFLECTOR ELECTRICAL DIAMETER=   735.15524 METERS
SURFACE APPROXIMATION ERROR=       1.5809351 MM
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NO OF MODULES ACROSS CORNERS=           45
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1008.26012 METERS
REFLECTOR PHYSICAL DIAMETER=     802.68258 METERS
REFLECTOR ELECTRICAL DIAMETER=   806.60809 METERS
SURFACE APPROXIMATION ERROR=       1.4408872 MM
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NO OF MODULES ACROSS CORNERS=           49
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1097.57617 METERS
REFLECTOR PHYSICAL DIAMETER=     873.78769 METERS
REFLECTOR ELECTRICAL DIAMETER=   878.06094 METERS
SURFACE APPROXIMATION ERROR=       1.3236327 MM
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NO OF MODULES ACROSS CORNERS=           53
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1186.89224 METERS
REFLECTOR PHYSICAL DIAMETER=     944.89281 METERS
REFLECTOR ELECTRICAL DIAMETER=   949.51379 METERS
SURFACE APPROXIMATION ERROR=       1.2240257 MM
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NO OF MODULES ACROSS CORNERS=           57
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1276.20833 METERS
REFLECTOR PHYSICAL DIAMETER=    1015.99793 METERS
REFLECTOR ELECTRICAL DIAMETER= 1020.96666 METERS
SURFACE APPROXIMATION ERROR=       1.1383610 MM
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NO OF MODULES ACROSS CORNERS=         61
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1365.52438 METERS
REFLECTOR PHYSICAL DIAMETER=    1087.10304 METERS
REFLECTOR ELECTRICAL DIAMETER= 1092.41951 METERS
SURFACE APPROXIMATION ERROR=       1.0639027 MM


NO OF MODULES ACROSS CORNERS=         65
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1454.84047 METERS
REFLECTOR PHYSICAL DIAMETER=    1158.20818 METERS
REFLECTOR ELECTRICAL DIAMETER= 1163.87238 METERS
SURFACE APPROXIMATION ERROR=       0.9985868 MM


NO OF MODULES ACROSS CORNERS=          5
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=        83.70865 METERS
REFLECTOR PHYSICAL DIAMETER=      66.64102 METERS
REFLECTOR ELECTRICAL DIAMETER=    66.96692 METERS
SURFACE APPROXIMATION ERROR=       9.1839657 MM


NO OF MODULES ACROSS CORNERS=          9
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       148.66580 METERS
REFLECTOR PHYSICAL DIAMETER=     118.35383 METERS
REFLECTOR ELECTRICAL DIAMETER=   118.93264 METERS
SURFACE APPROXIMATION ERROR=       5.1694989 MM


NO OF MODULES ACROSS CORNERS=         13
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       213.62294 METERS
REFLECTOR PHYSICAL DIAMETER=     170.06664 METERS
REFLECTOR ELECTRICAL DIAMETER=   170.89835 METERS
SURFACE APPROXIMATION ERROR=       3.5973107 MM
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NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        278.58008 METERS
REFLECTOR PHYSICAL DIAMETER=      221.77946 METERS
REFLECTOR ELECTRICAL DIAMETER=    222.86407 METERS
SURFACE APPROXIMATION ERROR=        2.7584354 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        343.53723 METERS
REFLECTOR PHYSICAL DIAMETER=      273.49227 METERS
REFLECTOR ELECTRICAL DIAMETER=    274.82978 METERS
SURFACE APPROXIMATION ERROR=        2.2368289 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        408.49437 METERS
REFLECTOR PHYSICAL DIAMETER=      325.20508 METERS
REFLECTOR ELECTRICAL DIAMETER=    326.79549 METERS
SURFACE APPROXIMATION ERROR=        1.8811220 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        473.45151 METERS
REFLECTOR PHYSICAL DIAMETER=      376.91790 METERS
REFLECTOR ELECTRICAL DIAMETER=    378.76121 METERS
SURFACE APPROXIMATION ERROR=        1.6230255 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        538.40865 METERS
REFLECTOR PHYSICAL DIAMETER=      428.63071 METERS
REFLECTOR ELECTRICAL DIAMETER=    430.72692 METERS
SURFACE APPROXIMATION ERROR=        1.4272084 MM
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NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       603.36579 METERS
REFLECTOR PHYSICAL DIAMETER=     480.34352 METERS
REFLECTOR ELECTRICAL DIAMETER=   482.69263 METERS
SURFACE APPROXIMATION ERROR=       1.2735551 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       668.32294 METERS
REFLECTOR PHYSICAL DIAMETER=     532.05634 METERS
REFLECTOR ELECTRICAL DIAMETER=   534.65835 METERS
SURFACE APPROXIMATION ERROR=       1.1497710 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       733.28009 METERS
REFLECTOR PHYSICAL DIAMETER=     583.76915 METERS
REFLECTOR ELECTRICAL DIAMETER=   586.62407 METERS
SURFACE APPROXIMATION ERROR=       1.0479179 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       798.23722 METERS
REFLECTOR PHYSICAL DIAMETER=     635.48196 METERS
REFLECTOR ELECTRICAL DIAMETER=   638.58978 METERS
SURFACE APPROXIMATION ERROR=       0.9626420 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       863.19436 METERS
REFLECTOR PHYSICAL DIAMETER=     687.19477 METERS
REFLECTOR ELECTRICAL DIAMETER=   690.55549 METERS
SURFACE APPROXIMATION ERROR=       0.8902005 MM
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NO OF MODULES ACROSS CORNERS=           57
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       928.15150 METERS
REFLECTOR PHYSICAL DIAMETER=     738.90759 METERS
REFLECTOR ELECTRICAL DIAMETER=   742.52120 METERS
SURFACE APPROXIMATION ERROR=       0.8278989 MM


NO OF MODULES ACROSS CORNERS=           61
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       993.10866 METERS
REFLECTOR PHYSICAL DIAMETER=     790.62040 METERS
REFLECTOR ELECTRICAL DIAMETER=   794.48692 METERS
SURFACE APPROXIMATION ERROR=       0.7737474 MM


NO OF MODULES ACROSS CORNERS=           65
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=      1058.06580 METERS
REFLECTOR PHYSICAL DIAMETER=     842.33321 METERS
REFLECTOR ELECTRICAL DIAMETER=   846.45264 METERS
SURFACE APPROXIMATION ERROR=       0.7262450 MM


NO OF MODULES ACROSS CORNERS=            5
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=        52.31791 METERS
REFLECTOR PHYSICAL DIAMETER=      41.65064 METERS
REFLECTOR ELECTRICAL DIAMETER=    41.85433 METERS
SURFACE APPROXIMATION ERROR=       5.7399784 MM


NO OF MODULES ACROSS CORNERS=            9
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=        92.91612 METERS
REFLECTOR PHYSICAL DIAMETER=      73.97114 METERS
REFLECTOR ELECTRICAL DIAMETER=    74.33290 METERS
SURFACE APPROXIMATION ERROR=       3.2309367 MM
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NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        133.51434 METERS
REFLECTOR PHYSICAL DIAMETER=      106.29165 METERS
REFLECTOR ELECTRICAL DIAMETER=    106.81147 METERS
SURFACE APPROXIMATION ERROR=        2.2483192 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        174.11255 METERS
REFLECTOR PHYSICAL DIAMETER=      138.61216 METERS
REFLECTOR ELECTRICAL DIAMETER=    139.29004 METERS
SURFACE APPROXIMATION ERROR=        1.7240221 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        214.71077 METERS
REFLECTOR PHYSICAL DIAMETER=      170.93267 METERS
REFLECTOR ELECTRICAL DIAMETER=    171.76861 METERS
SURFACE APPROXIMATION ERROR=        1.3980180 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        255.30898 METERS
REFLECTOR PHYSICAL DIAMETER=      203.25318 METERS
REFLECTOR ELECTRICAL DIAMETER=    204.24718 METERS
SURFACE APPROXIMATION ERROR=        1.1757012 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.25
FOCAL LENGTH OF REFLECTOR=        295.90720 METERS
REFLECTOR PHYSICAL DIAMETER=      235.57368 METERS
REFLECTOR ELECTRICAL DIAMETER=    236.72576 METERS
SURFACE APPROXIMATION ERROR=        1.0143909 MM
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NO OF MODULES ACROSS CORNERS=            33
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       336.50541 METERS
REFLECTOR PHYSICAL DIAMETER=     267.89419 METERS
REFLECTOR ELECTRICAL DIAMETER=   269.20433 METERS
SURFACE APPROXIMATION ERROR=       0.8920052 MM


NO OF MODULES ACROSS CORNERS=            37
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       377.10363 METERS
REFLECTOR PHYSICAL DIAMETER=     300.21470 METERS
REFLECTOR ELECTRICAL DIAMETER=   301.68290 METERS
SURFACE APPROXIMATION ERROR=       0.7959719 MM


NO OF MODULES ACROSS CORNERS=            41
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       417.70184 METERS
REFLECTOR PHYSICAL DIAMETER=     332.53521 METERS
REFLECTOR ELECTRICAL DIAMETER=   334.16147 METERS
SURFACE APPROXIMATION ERROR=       0.7186068 MM


NO OF MODULES ACROSS CORNERS=            45
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       458.30006 METERS
REFLECTOR PHYSICAL DIAMETER=     364.85572 METERS
REFLECTOR ELECTRICAL DIAMETER=   366.64005 METERS
SURFACE APPROXIMATION ERROR=       0.6549487 MM


NO OF MODULES ACROSS CORNERS=            49
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       498.89826 METERS
REFLECTOR PHYSICAL DIAMETER=     397.17622 METERS
REFLECTOR ELECTRICAL DIAMETER=   399.11861 METERS
SURFACE APPROXIMATION ERROR=       0.6016512 MM
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NO OF MODULES ACROSS CORNERS=           53
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       539.49648 METERS
REFLECTOR PHYSICAL DIAMETER=     429.49673 METERS
REFLECTOR ELECTRICAL DIAMETER=  431.59718 METERS
SURFACE APPROXIMATION ERROR=      0.5563753 MM
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NO OF MODULES ACROSS CORNERS=           57
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       580.09470 METERS
REFLECTOR PHYSICAL DIAMETER=     461.81724 METERS
REFLECTOR ELECTRICAL DIAMETER=  464.07576 METERS
SURFACE APPROXIMATION ERROR=      0.5174368 MM
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NO OF MODULES ACROSS CORNERS=           61
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       620.69291 METERS
REFLECTOR PHYSICAL DIAMETER=     494.13775 METERS
REFLECTOR ELECTRICAL DIAMETER=  496.55433 METERS
SURFACE APPROXIMATION ERROR=      0.4835921 MM
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NO OF MODULES ACROSS CORNERS=           65
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.25
FOCAL LENGTH OF REFLECTOR=       661.29112 METERS
REFLECTOR PHYSICAL DIAMETER=     526.45826 METERS
REFLECTOR ELECTRICAL DIAMETER=  529.03290 METERS
SURFACE APPROXIMATION ERROR=      0.4539031 MM
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NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        175.53076 METERS
REFLECTOR PHYSICAL DIAMETER=      116.62178 METERS
REFLECTOR ELECTRICAL DIAMETER=    117.02051 METERS
SURFACE APPROXIMATION ERROR=       13.4331638 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        311.74100 METERS
REFLECTOR PHYSICAL DIAMETER=      207.11920 METERS
REFLECTOR ELECTRICAL DIAMETER=    207.82734 METERS
SURFACE APPROXIMATION ERROR=        7.5620744 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        447.95126 METERS
REFLECTOR PHYSICAL DIAMETER=      297.61663 METERS
REFLECTOR ELECTRICAL DIAMETER=    298.63417 METERS
SURFACE APPROXIMATION ERROR=        5.2623661 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        584.16151 METERS
REFLECTOR PHYSICAL DIAMETER=      388.11405 METERS
REFLECTOR ELECTRICAL DIAMETER=    389.44100 METERS
SURFACE APPROXIMATION ERROR=        4.0352458 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=    28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        720.37175 METERS
REFLECTOR PHYSICAL DIAMETER=      478.61147 METERS
REFLECTOR ELECTRICAL DIAMETER=    480.24783 METERS
SURFACE APPROXIMATION ERROR=        3.2722159 MM
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NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       856.58200 METERS
REFLECTOR PHYSICAL DIAMETER=     569.10889 METERS
REFLECTOR ELECTRICAL DIAMETER=   571.05466 METERS
SURFACE APPROXIMATION ERROR=       2.7518658 MM
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NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       992.79224 METERS
REFLECTOR PHYSICAL DIAMETER=     659.60632 METERS
REFLECTOR ELECTRICAL DIAMETER=   661.86150 METERS
SURFACE APPROXIMATION ERROR=       2.3743040 MM
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NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=      1129.00249 METERS
REFLECTOR PHYSICAL DIAMETER=     750.10374 METERS
REFLECTOR ELECTRICAL DIAMETER=   752.66833 METERS
SURFACE APPROXIMATION ERROR=       2.0878477 MM
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NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=      1265.21275 METERS
REFLECTOR PHYSICAL DIAMETER=     840.60117 METERS
REFLECTOR ELECTRICAL DIAMETER=   843.47517 METERS
SURFACE APPROXIMATION ERROR=       1.8630713 MM
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NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=      1401.42299 METERS
REFLECTOR PHYSICAL DIAMETER=     931.09859 METERS
REFLECTOR ELECTRICAL DIAMETER=   934.28199 METERS
SURFACE APPROXIMATION ERROR=       1.6819896 MM
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NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       1537.63326 METERS
REFLECTOR PHYSICAL DIAMETER=     1021.59602 METERS
REFLECTOR ELECTRICAL DIAMETER= 1025.08884 METERS
SURFACE APPROXIMATION ERROR=       1.5329903 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       1673.84349 METERS
REFLECTOR PHYSICAL DIAMETER=     1112.09343 METERS
REFLECTOR ELECTRICAL DIAMETER= 1115.89566 METERS
SURFACE APPROXIMATION ERROR=       1.4082412 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       1810.05373 METERS
REFLECTOR PHYSICAL DIAMETER=     1202.59085 METERS
REFLECTOR ELECTRICAL DIAMETER= 1206.70248 METERS
SURFACE APPROXIMATION ERROR=       1.3022675 MM


NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       1946.26396 METERS
REFLECTOR PHYSICAL DIAMETER=     1293.08827 METERS
REFLECTOR ELECTRICAL DIAMETER= 1297.50931 METERS
SURFACE APPROXIMATION ERROR=       1.2111272 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       2082.47421 METERS
REFLECTOR PHYSICAL DIAMETER=     1383.58569 METERS
REFLECTOR ELECTRICAL DIAMETER= 1388.31615 METERS
SURFACE APPROXIMATION ERROR=       1.1319095 MM
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NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   28.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       2218.68448 METERS
REFLECTOR PHYSICAL DIAMETER=     1474.08313 METERS
REFLECTOR ELECTRICAL DIAMETER=   1479.12299 METERS
SURFACE APPROXIMATION ERROR=        1.0624187 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        137.91702 METERS
REFLECTOR PHYSICAL DIAMETER=       91.63140 METERS
REFLECTOR ELECTRICAL DIAMETER=     91.94468 METERS
SURFACE APPROXIMATION ERROR=       10.5546287 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        244.93936 METERS
REFLECTOR PHYSICAL DIAMETER=      162.73652 METERS
REFLECTOR ELECTRICAL DIAMETER=    163.29291 METERS
SURFACE APPROXIMATION ERROR=        5.9416299 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        351.96170 METERS
REFLECTOR PHYSICAL DIAMETER=      233.84163 METERS
REFLECTOR ELECTRICAL DIAMETER=    234.64113 METERS
SURFACE APPROXIMATION ERROR=        4.1347162 MM


NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        458.98404 METERS
REFLECTOR PHYSICAL DIAMETER=      304.94675 METERS
REFLECTOR ELECTRICAL DIAMETER=    305.98936 METERS
SURFACE APPROXIMATION ERROR=        3.1705504 MM
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NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       566.00637 METERS
REFLECTOR PHYSICAL DIAMETER=     376.05187 METERS
REFLECTOR ELECTRICAL DIAMETER=   377.33758 METERS
SURFACE APPROXIMATION ERROR=       2.5710268 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       673.02871 METERS
REFLECTOR PHYSICAL DIAMETER=     447.15699 METERS
REFLECTOR ELECTRICAL DIAMETER=   448.68581 METERS
SURFACE APPROXIMATION ERROR=       2.1621803 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       780.05106 METERS
REFLECTOR PHYSICAL DIAMETER=     518.26211 METERS
REFLECTOR ELECTRICAL DIAMETER=   520.03403 METERS
SURFACE APPROXIMATION ERROR=       1.8655246 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       887.07339 METERS
REFLECTOR PHYSICAL DIAMETER=     589.36723 METERS
REFLECTOR ELECTRICAL DIAMETER=   591.38226 METERS
SURFACE APPROXIMATION ERROR=       1.6404518 MM


NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       994.09573 METERS
REFLECTOR PHYSICAL DIAMETER=     660.47234 METERS
REFLECTOR ELECTRICAL DIAMETER=   662.73048 METERS
SURFACE APPROXIMATION ERROR=       1.4638418 MM
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NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER, RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=      1101.11807 METERS
REFLECTOR PHYSICAL DIAMETER=     731.57746 METERS
REFLECTOR ELECTRICAL DIAMETER=  734.07871 METERS
SURFACE APPROXIMATION ERROR=      1.3215632 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=      1208.14040 METERS
REFLECTOR PHYSICAL DIAMETER=     802.68258 METERS
REFLECTOR ELECTRICAL DIAMETER=  805.42693 METERS
SURFACE APPROXIMATION ERROR=      1.2044924 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=      1315.16274 METERS
REFLECTOR PHYSICAL DIAMETER=     873.78769 METERS
REFLECTOR ELECTRICAL DIAMETER=  876.77515 METERS
SURFACE APPROXIMATION ERROR=      1.1064752 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=      1422.18506 METERS
REFLECTOR PHYSICAL DIAMETER=     944.89281 METERS
REFLECTOR ELECTRICAL DIAMETER=  948.12337 METERS
SURFACE APPROXIMATION ERROR=      1.0232102 MM


NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=      1529.20741 METERS
REFLECTOR PHYSICAL DIAMETER=    1015.99793 METERS
REFLECTOR ELECTRICAL DIAMETER= 1019.47161 METERS
SURFACE APPROXIMATION ERROR=      0.9515999 MM
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NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       1636.22974 METERS
REFLECTOR PHYSICAL DIAMETER=     1087.10304 METERS
REFLECTOR ELECTRICAL DIAMETER=   1090.81982 METERS
SURFACE APPROXIMATION ERROR=       0.8893575 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   22.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       1743.25209 METERS
REFLECTOR PHYSICAL DIAMETER=     1158.20818 METERS
REFLECTOR ELECTRICAL DIAMETER=   1162.16806 METERS
SURFACE APPROXIMATION ERROR=       0.8347575 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        100.30329 METERS
REFLECTOR PHYSICAL DIAMETER=       66.64102 METERS
REFLECTOR ELECTRICAL DIAMETER=     66.86886 METERS
SURFACE APPROXIMATION ERROR=       7.6760936 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        178.13772 METERS
REFLECTOR PHYSICAL DIAMETER=      118.35383 METERS
REFLECTOR ELECTRICAL DIAMETER=    118.75848 METERS
SURFACE APPROXIMATION ERROR=       4.3211854 MM


NO OF MODULES ACROSS CORNERS=          13
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=        255.97215 METERS
REFLECTOR PHYSICAL DIAMETER=      170.06664 METERS
REFLECTOR ELECTRICAL DIAMETER=    170.64810 METERS
SURFACE APPROXIMATION ERROR=       3.0070663 MM
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NO OF MODULES ACROSS CORNERS=          17
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        333.80657 METERS
REFLECTOR PHYSICAL DIAMETER=      221.77946 METERS
REFLECTOR ELECTRICAL DIAMETER=    222.53771 METERS
SURFACE APPROXIMATION ERROR=        2.3058548 MM


NO OF MODULES ACROSS CORNERS=          21
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        411.64100 METERS
REFLECTOR PHYSICAL DIAMETER=      273.49227 METERS
REFLECTOR ELECTRICAL DIAMETER=    274.42733 METERS
SURFACE APPROXIMATION ERROR=        1.8698376 MM


NO OF MODULES ACROSS CORNERS=          25
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        489.47543 METERS
REFLECTOR PHYSICAL DIAMETER=      325.20508 METERS
REFLECTOR ELECTRICAL DIAMETER=    326.31695 METERS
SURFACE APPROXIMATION ERROR=        1.5724947 MM


NO OF MODULES ACROSS CORNERS=          29
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        567.30985 METERS
REFLECTOR PHYSICAL DIAMETER=      376.91790 METERS
REFLECTOR ELECTRICAL DIAMETER=    378.20657 METERS
SURFACE APPROXIMATION ERROR=        1.3567452 MM


NO OF MODULES ACROSS CORNERS=          33
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        645.14428 METERS
REFLECTOR PHYSICAL DIAMETER=      428.63071 METERS
REFLECTOR ELECTRICAL DIAMETER=    430.09619 METERS
SURFACE APPROXIMATION ERROR=        1.1930558 MM
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NO OF MODULES ACROSS CORNERS=          37
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       722.97871 METERS
REFLECTOR PHYSICAL DIAMETER=     480.34352 METERS
REFLECTOR ELECTRICAL DIAMETER=   481.98581 METERS
SURFACE APPROXIMATION ERROR=       1.0646122 MM


NO OF MODULES ACROSS CORNERS=          41
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       800.81314 METERS
REFLECTOR PHYSICAL DIAMETER=     532.05634 METERS
REFLECTOR ELECTRICAL DIAMETER=   533.87543 METERS
SURFACE APPROXIMATION ERROR=       0.9611369 MM


NO OF MODULES ACROSS CORNERS=          45
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       878.64757 METERS
REFLECTOR PHYSICAL DIAMETER=     583.76915 METERS
REFLECTOR ELECTRICAL DIAMETER=   585.76505 METERS
SURFACE APPROXIMATION ERROR=       0.8759945 MM


NO OF MODULES ACROSS CORNERS=          49
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       956.48199 METERS
REFLECTOR PHYSICAL DIAMETER=     635.48196 METERS
REFLECTOR ELECTRICAL DIAMETER=   637.65466 METERS
SURFACE APPROXIMATION ERROR=       0.8047093 MM


NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=      1034.31641 METERS
REFLECTOR PHYSICAL DIAMETER=     687.19477 METERS
REFLECTOR ELECTRICAL DIAMETER=   689.54427 METERS
SURFACE APPROXIMATION ERROR=       0.7441529 MM
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NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        1112.15083 METERS
REFLECTOR PHYSICAL DIAMETER=       738.90759 METERS
REFLECTOR ELECTRICAL DIAMETER=     741.43389 METERS
SURFACE APPROXIMATION ERROR=         0.6920727 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        1189.98528 METERS
REFLECTOR PHYSICAL DIAMETER=       790.62040 METERS
REFLECTOR ELECTRICAL DIAMETER=     793.32352 METERS
SURFACE APPROXIMATION ERROR=         0.6468055 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=    16.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=        1267.81970 METERS
REFLECTOR PHYSICAL DIAMETER=       842.33321 METERS
REFLECTOR ELECTRICAL DIAMETER=     845.21313 METERS
SURFACE APPROXIMATION ERROR=         0.6070964 MM


NO OF MODULES ACROSS CORNERS=           5
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=          62.68956 METERS
REFLECTOR PHYSICAL DIAMETER=        41.65064 METERS
REFLECTOR ELECTRICAL DIAMETER=      41.79304 METERS
SURFACE APPROXIMATION ERROR=         4.7975584 MM


NO OF MODULES ACROSS CORNERS=           9
MODULE DIAMETER ACROSS CORNERS=    10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=     1.50
FOCAL LENGTH OF REFLECTOR=         111.33607 METERS
REFLECTOR PHYSICAL DIAMETER=        73.97114 METERS
REFLECTOR ELECTRICAL DIAMETER=      74.22405 METERS
SURFACE APPROXIMATION ERROR=         2.7007408 MM
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NO OF MODULES ACROSS CORNERS=           13
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       159.98259 METERS
REFLECTOR PHYSICAL DIAMETER=     106.29165 METERS
REFLECTOR ELECTRICAL DIAMETER=  106.65506 METERS
SURFACE APPROXIMATION ERROR=      1.8794165 MM


NO OF MODULES ACROSS CORNERS=           17
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       208.62911 METERS
REFLECTOR PHYSICAL DIAMETER=     138.61216 METERS
REFLECTOR ELECTRICAL DIAMETER=  139.08607 METERS
SURFACE APPROXIMATION ERROR=      1.4411593 MM


NO OF MODULES ACROSS CORNERS=           21
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       257.27562 METERS
REFLECTOR PHYSICAL DIAMETER=     170.93267 METERS
REFLECTOR ELECTRICAL DIAMETER=  171.51708 METERS
SURFACE APPROXIMATION ERROR=      1.1686485 MM


NO OF MODULES ACROSS CORNERS=           25
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       305.92214 METERS
REFLECTOR PHYSICAL DIAMETER=     203.25318 METERS
REFLECTOR ELECTRICAL DIAMETER=  203.94809 METERS
SURFACE APPROXIMATION ERROR=      0.9828092 MM


NO OF MODULES ACROSS CORNERS=           29
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       354.56866 METERS
REFLECTOR PHYSICAL DIAMETER=     235.57368 METERS
REFLECTOR ELECTRICAL DIAMETER=  236.37911 METERS
SURFACE APPROXIMATION ERROR=      0.8479657 MM
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NO OF MODULES ACROSS CORNERS=             33
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       403.21518 METERS
REFLECTOR PHYSICAL DIAMETER=     267.89419 METERS
REFLECTOR ELECTRICAL DIAMETER=   268.81012 METERS
SURFACE APPROXIMATION ERROR=       0.7456599 MM


NO OF MODULES ACROSS CORNERS=             37
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       451.86170 METERS
REFLECTOR PHYSICAL DIAMETER=     300.21470 METERS
REFLECTOR ELECTRICAL DIAMETER=   301.24113 METERS
SURFACE APPROXIMATION ERROR=       0.6653826 MM


NO OF MODULES ACROSS CORNERS=             41
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       500.50821 METERS
REFLECTOR PHYSICAL DIAMETER=     332.53521 METERS
REFLECTOR ELECTRICAL DIAMETER=   333.67214 METERS
SURFACE APPROXIMATION ERROR=       0.6007106 MM


NO OF MODULES ACROSS CORNERS=             45
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       549.15473 METERS
REFLECTOR PHYSICAL DIAMETER=     364.85572 METERS
REFLECTOR ELECTRICAL DIAMETER=   366.10315 METERS
SURFACE APPROXIMATION ERROR=       0.5474965 MM


NO OF MODULES ACROSS CORNERS=             49
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       597.80124 METERS
REFLECTOR PHYSICAL DIAMETER=     397.17622 METERS
REFLECTOR ELECTRICAL DIAMETER=   398.53416 METERS
SURFACE APPROXIMATION ERROR=       0.5029433 MM
```
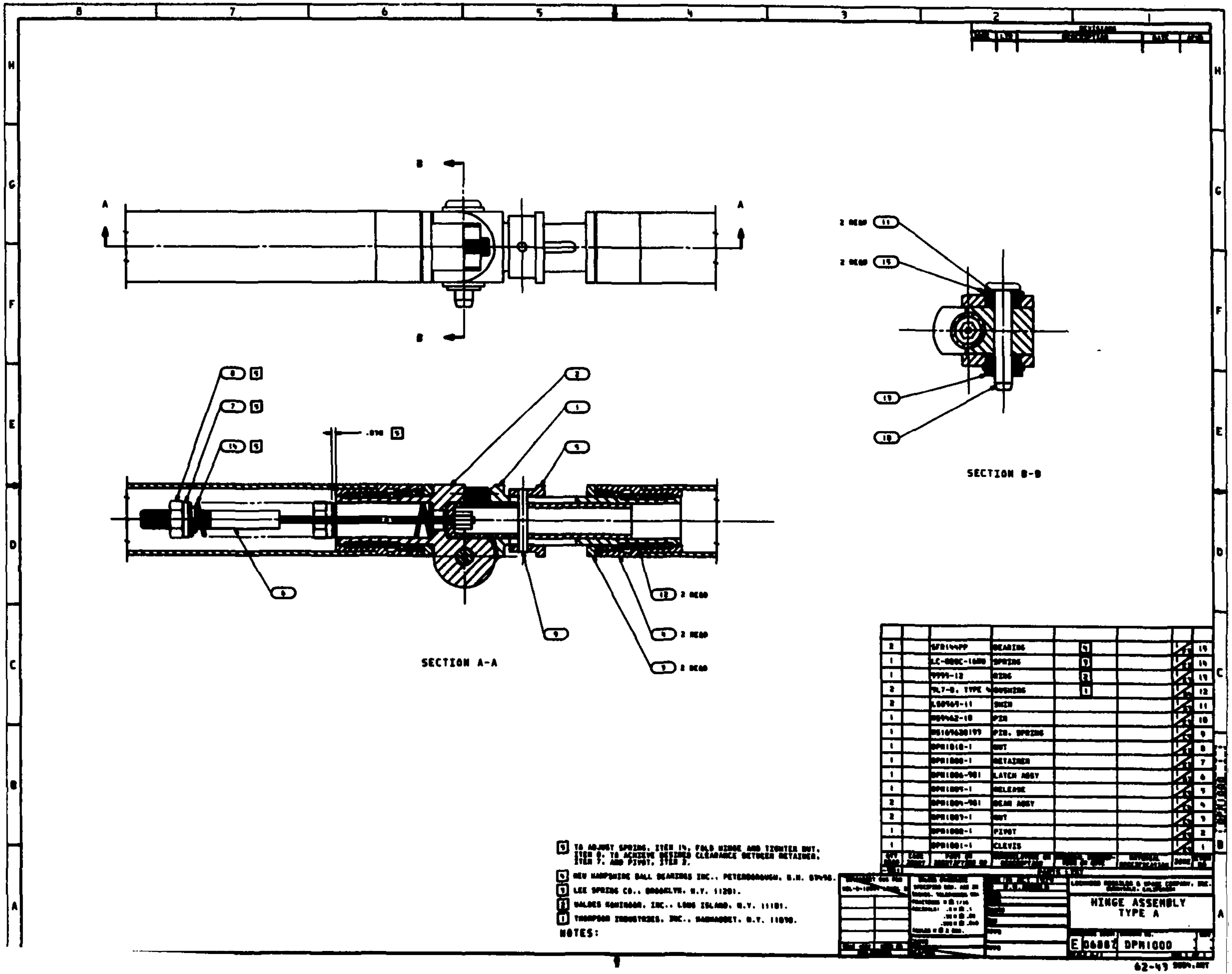
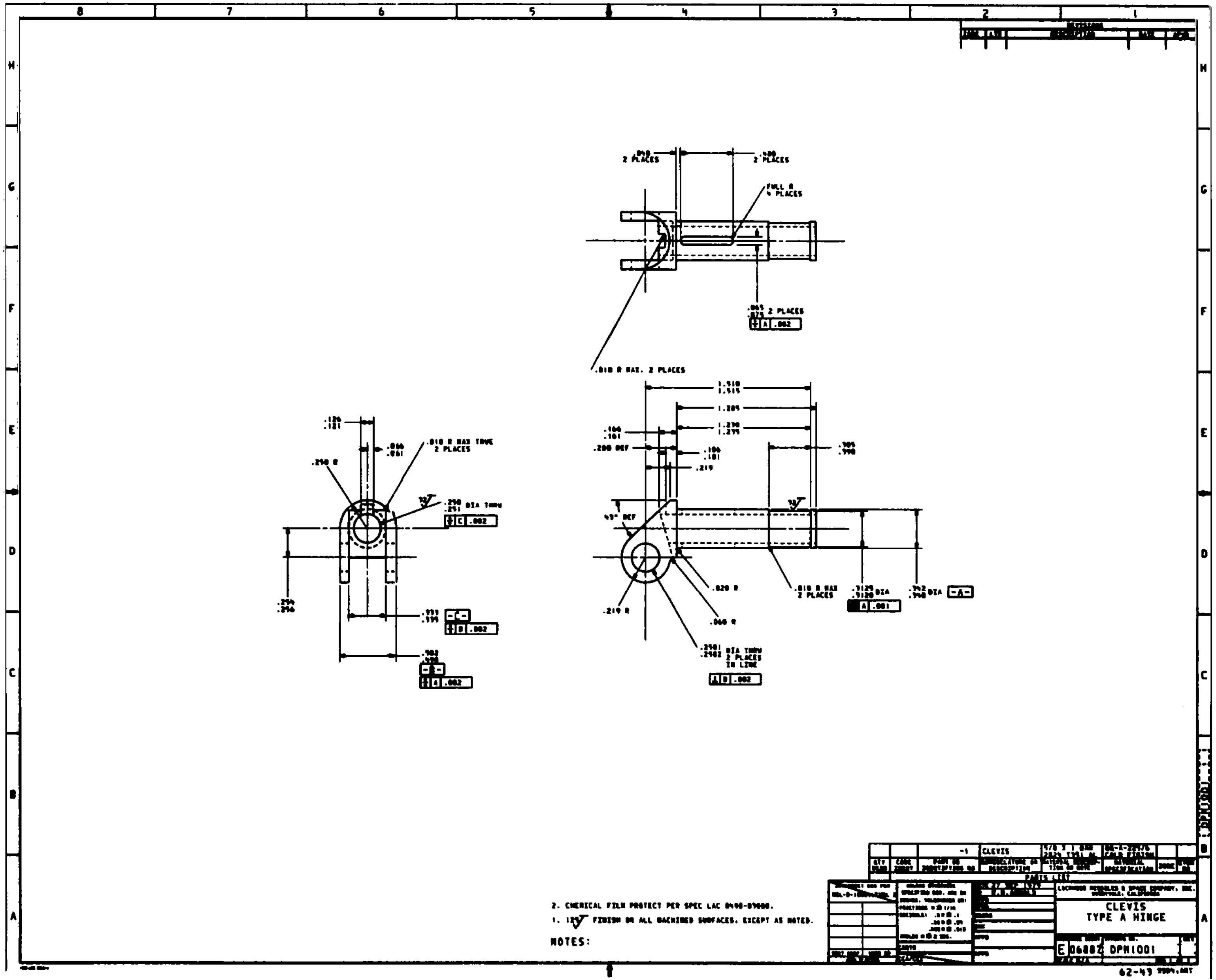

```
NO OF MODULES ACROSS CORNERS=          53
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       646.44776 METERS
REFLECTOR PHYSICAL DIAMETER=     429.49673 METERS
REFLECTOR ELECTRICAL DIAMETER=   430.96517 METERS
SURFACE APPROXIMATION ERROR=       0.4650955 MM


NO OF MODULES ACROSS CORNERS=          57
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       695.09428 METERS
REFLECTOR PHYSICAL DIAMETER=     461.81724 METERS
REFLECTOR ELECTRICAL DIAMETER=   463.39619 METERS
SURFACE APPROXIMATION ERROR=       0.4325454 MM


NO OF MODULES ACROSS CORNERS=          61
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       743.74079 METERS
REFLECTOR PHYSICAL DIAMETER=     494.13775 METERS
REFLECTOR ELECTRICAL DIAMETER=   495.82719 METERS
SURFACE APPROXIMATION ERROR=       0.4042534 MM


NO OF MODULES ACROSS CORNERS=          65
MODULE DIAMETER ACROSS CORNERS=   10.000 METERS
FOCAL LENGTH TO DIAMETER RATIO=    1.50
FOCAL LENGTH OF REFLECTOR=       792.38731 METERS
REFLECTOR PHYSICAL DIAMETER=     526.45826 METERS
REFLECTOR ELECTRICAL DIAMETER=   528.25821 METERS
SURFACE APPROXIMATION ERROR=       0.3794352 MM
EXIT
```

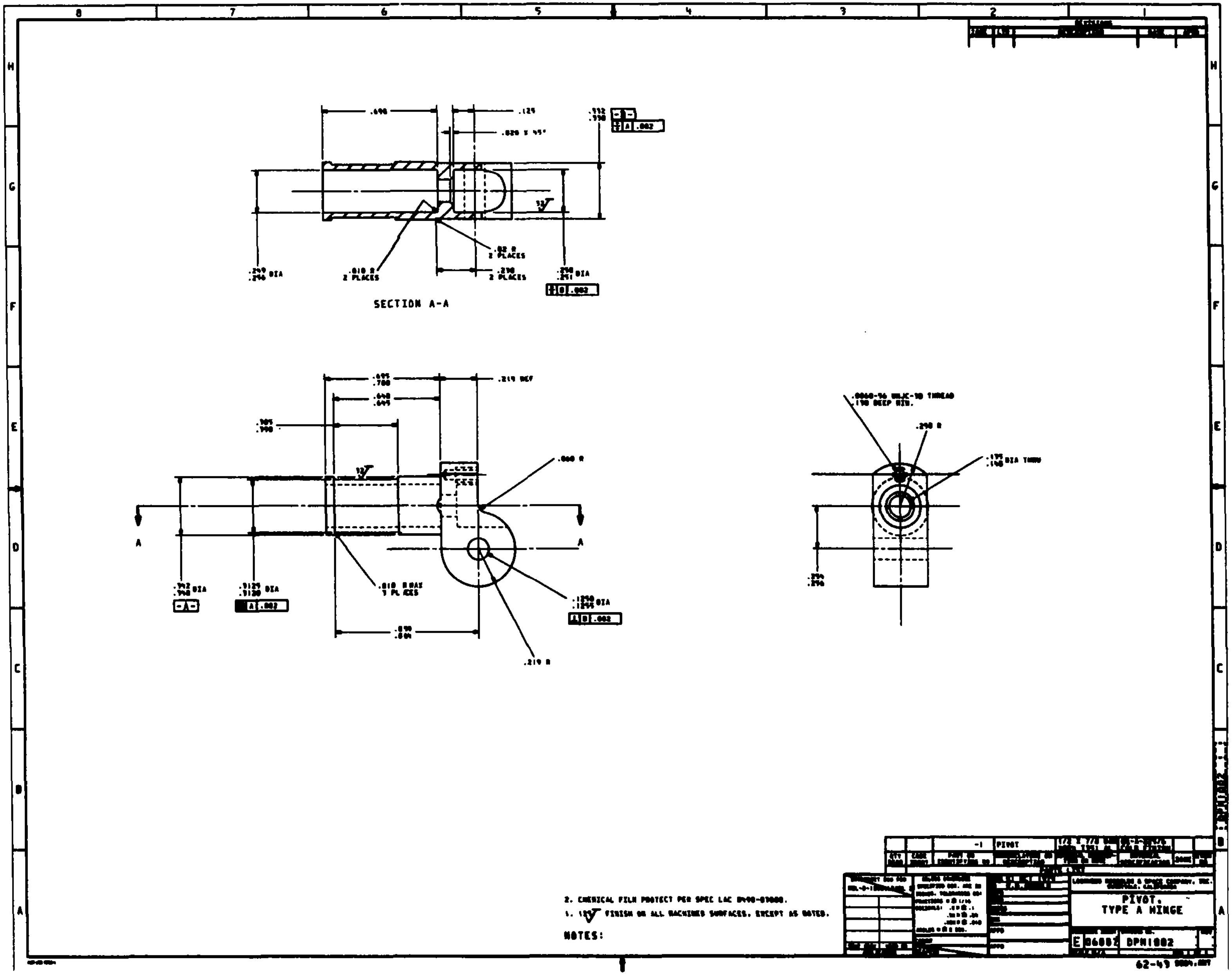
APPENDIX B

MODULAR ANTENNA MODEL DETAIL DRAWINGS

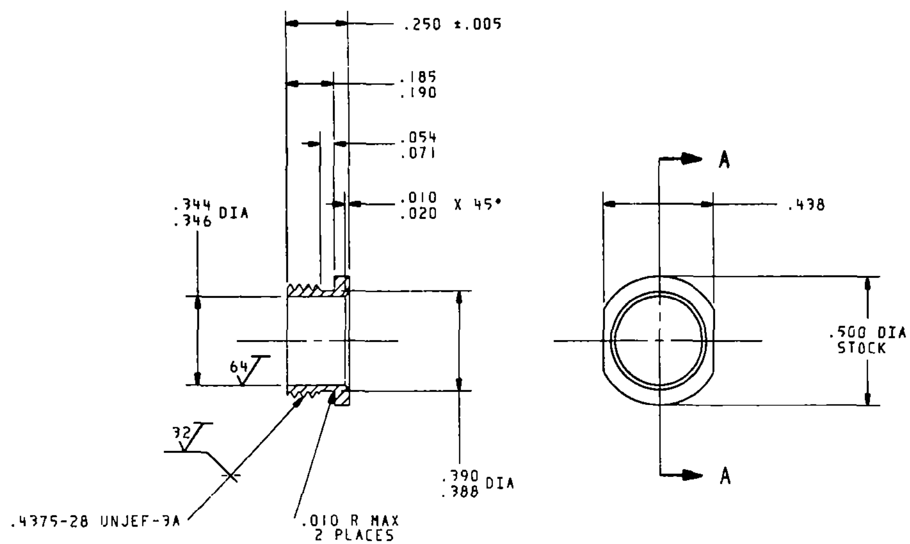

SECTION A-A
SECTION B-B
2 REQD
TO ADJUST SPRING, ITEM 14, FOLD HINGE AND TIGHTEN NUT, ITEM 8, TO ACHIEVE DESIRED CLEARANCE BETWEEN RETAINER, ITEM 7, AND PIVOT, ITEM 2.
NEW HAMPSHIRE BALL BEARINGS INC., PETERBOROUGH, N.H.
LEE SPRING CO., BROOKLYN, N.Y. 11201.
THOMPSON INDUSTRIES, INC., MANHASSET, N.Y. 11030.
NOTES:
BEARING
SPRING
RING
BUSHING
SHIM
PIN
PIN, SPRING
NUT
RETAINER
LATCH ASSY
RELEASE
BEAM ASSY
NUT
PIVOT
CLEVIS
DPN1000-1
DPN1006-901
DPN1004-901
DPN1001-1
HINGE ASSEMBLY
TYPE A
E 06887 DPN1000
62-49



NOTES:
1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
2. CHEMICAL FILM PROTECT PER SPEC LAC 0400-07000.
CLEVIS
TYPE A HINGE
E 06887 DPM1001
PARTS LIST
62-43


SECTION A-A
NOTES:
1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
2. CHEMICAL FILM PROTECT PER SPEC LAC 0490-07000.
PIVOT,
TYPE A HINGE
-1
PIVOT
E
DPN1002
62-43

ZONE	LTR	DESCRIPTION	DATE	APVD
REVISIONS				



SECTION A-A

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	NUT	1/2 DIA ROD 2024 T351 AL	QQ-A-225/6 COLD FINISH		

PARTS LIST

NOTES:

1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
2. *CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.*

MIL-D-1000, LEVEL 2

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR

CCA/CEI

DATE 01 OCT 1979
DR R.H.ARNOLD
APPD
APPD
ENGRG
CHK
APPD
APPD

LOCKHEED MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA

NUT,
TYPE A HINGE

SIZE C | CODE IDENT 06887 | DRAWING NO. DPM1003 | REV

SCALE N/A | SH 1 OF 1

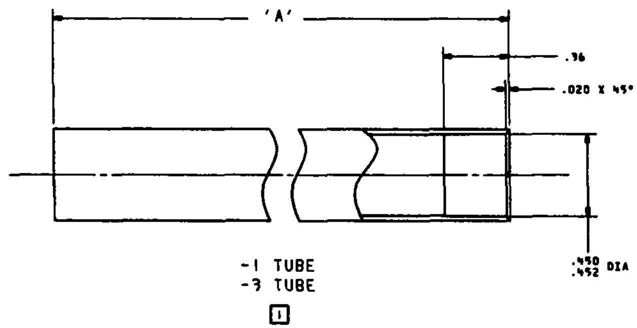
DPM1003

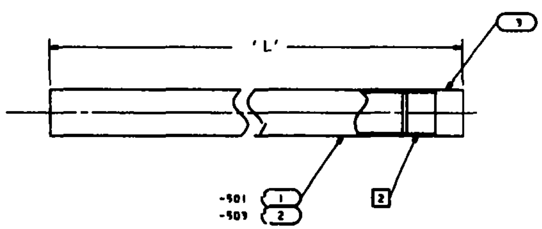
62-43 SSD4.ANT

DASH NO.	DIM. 'A' ±.005	DIM. 'L' ±.005
-1	23.995	24.315
-3	24.646	24.996
-5	28.995	29.315
-7	35.225	35.545
-9	13.907	13.627
-11	13.957	14.227
-13	27.684	N/A
-15	28.494	N/A

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APVD





-511	-509	-507	-505	QTY REQD -503	QTY REQD -501	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
							-15	TUBE	1/2 ODX.028W TUBE FIBREGLASS			9
							-13	TUBE	1/2 ODX.028W TUBE FIBREGLASS			8
1							-11	TUBE	1/2 ODX.028W TUBE FIBREGLASS			7
	1						-9	TUBE	1/2 ODX.028W TUBE FIBREGLASS			6
		1					-7	TUBE	1/2 ODX.028W TUBE FIBREGLASS			5
			1				-5	TUBE	1/2 ODX.028W TUBE FIBREGLASS			4
			1	1	1		DPM1009-1	END				3
				1			-3	TUBE	1/2 ODX.028W TUBE FIBREGLASS	NEMA G		2
					1		-1	TUBE	1/2 ODX.028W TUBE FIBREGLASS	NEMA G		1

PARTS LIST

NOTES:

1. CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.
2. BOND PER SPEC LAC

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16 DECIMALS: .XX = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES = ± 2 DEG.

DATE 05 OCT 1979
DR E.H. ARNOLD

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

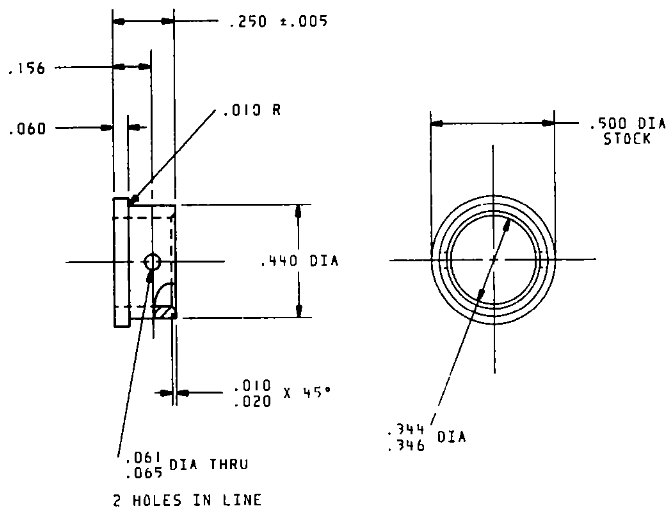
BEAM ASSEMBLY, DEPLOYABLE MODULE

SIZE D CODE IDENT 06887 DRAWING NO. DPM1004

SCALE N/A SH 1 OF 1

62-43 SSD4.ANT

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APVD



		-1	RELEASE	1/2 DIA ROD 2024 T351 AL	QQ-A-225/6 COLD FINISH		
QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
	PARTS LIST						

2. ANODIZE PER SPEC LAC 0494-020000, COLOR INSIGNIA BLUE (NO 35044) PER FED STD 595.

1. 125√ FINISH ON ALL MACHINED SURFACES.

NOTES:

MIL-D-1000, LEVEL 2

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG

CONTR
CCA/CEI

DATE 01 OCT 1979
DR R.H.ARNOLD
APPD
APPD
ENGRG
CHK
APPD
APPD

LOCKHEED MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA

RELEASE, LATCH
TYPE A HINGE

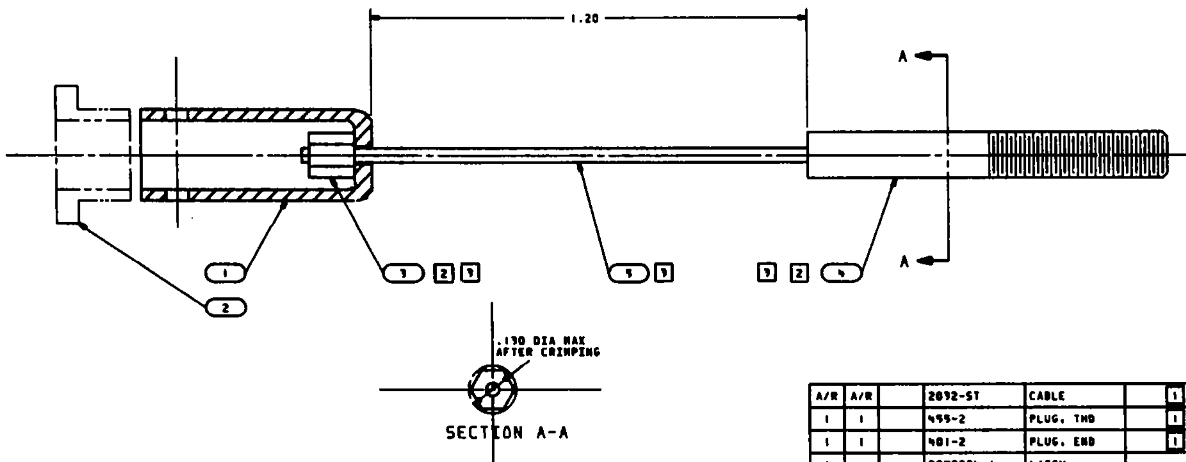
SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM1005	
SCALE N/A		SH 1 OF 1	

DPM1005

62-43 5504.ANT

ZONE	LTR	DESCRIPTION	DATE	APVD

REVISIONS



A/R	A/R		2032-ST	CABLE	1			5
1	1		455-2	PLUG, THD	1			4
1	1		401-2	PLUG, END	1			3
1			DPM3004-1	LATCH				2
	1		DPM1007-1	LATCH				1
QTY REQD	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
-903	-901	PARTS LIST						

3 AFTER CRIMPING, APPLY 20 LB FORCE TO CABLE BY PULLING ON PLUGS.

2 USE SAVE CRIMPING TOOL NO. T-105.

1 SAVE INDUSTRIES, INC., POMPTON LAKES, N.J. 07442.

NOTES:

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16 DECIMALS: .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES = ± 2 DEG.

DATE 03 OCT 1979
DR R.H. ARNOLD

LOCKHEED MISSILES & SPACE COMPANY

LATCH ASSY TYPE A HINGE

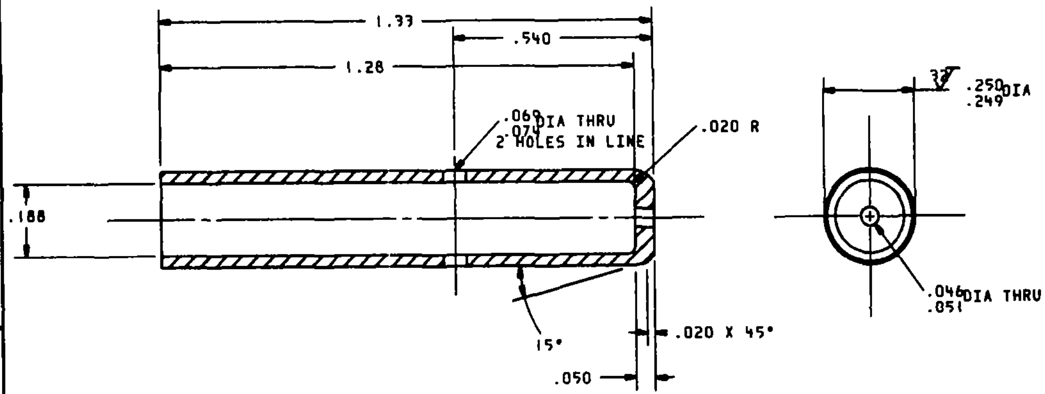
D 06887 DPM1006

SCALE N/A SH 1 OF 1

62-43 5504.ANT

REVISIONS

LTR	DESCRIPTION	DATE	APVD



DPM1007

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	LATCH	5/16 DIA ROD 2024 T4 AL	QQ-A-225/6 COLD FINISH		

PARTS LIST

NOTES:

1. 125√ FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.

INTERPRET DWG PER MIL-D-1000, LEVEL 2

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR
CCA/CEI

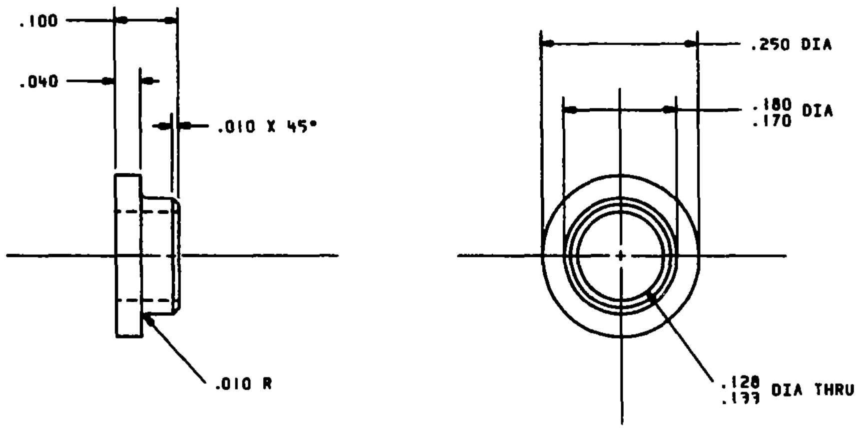
DATE	03 OCT 1979
DR	R.H.ARNOLD
APPD	
APPD	
ENGRG	
CHK	
APPD	
APPD	

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

LATCH
TYPE A HINGE

SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM1007	
SCALE N/A			SH 1 OF 1

42-43 5504.ANT



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	RETAINER	5/16 DIA ROD 2024 T4 AL	QQ-A-225/6 COLD FINISH		

PARTS LIST

NOTES:

1. 125√ FINISH ON ALL MACHINED SURFACES.
2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.

INTERPRET DWG PER MIL-D-1000, LEVEL 2

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR
CCA/CEI

DATE 03 OCT 1979
DR R.H.ARNOLD
APPD
APPD
ENGRG
CHK
APPD
APPD

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

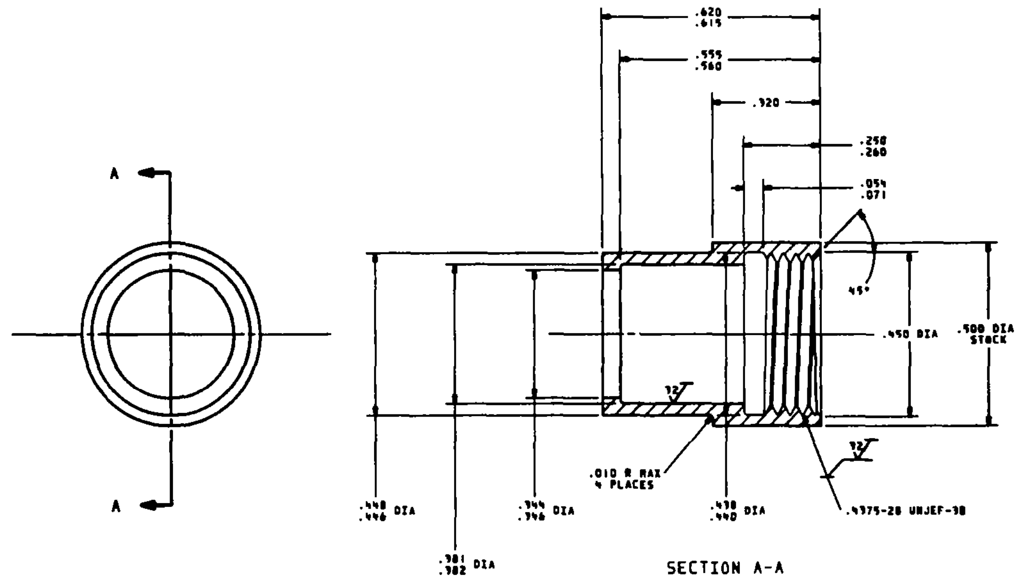
RETAINER, SPRING TYPE A HINGE

SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM1008	

SCALE N/A SH 1 OF 1

DPM1008

62-43 SSD4.ANT



SECTION A-A

2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-09000.

1. 125 FINISH ON ALL MACHINED SURFACES. EXCEPT AS NOTED.

NOTES:

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	END	1/2 DIA ROD 2024 T351 AL	QQ-A-225/6 COLD FINISH		

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16 DECIMALS: .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES = ± 2 DEG.

DATE 31 OCT 1978

R.H. ARNOLD

LOCKHEED MISSILES & SPACE COMPANY

END, THREADED
TYPE A HINGE

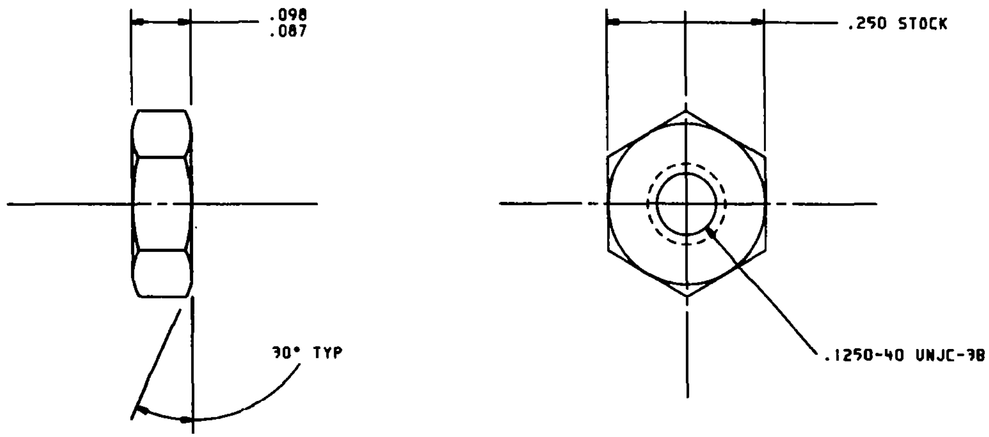
D 06887 DPM1009

SCALE 2/1

62-43 SS04.ANT

LTR	DESCRIPTION	DATE	APVD

REVISIONS



DPM1010

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	NUT	1/4 HEX BAR 321/347 CRES	QQ-S-763 COLD FINISH		

PARTS LIST

NOTES:

1. 125√ FINISH ON ALL MACHINED SURFACES.
2. MAY ALSO BE MADE FROM MS35649-244.

INTERPRET DWG PER MIL-D-1000, LEVEL 2

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .09
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR
CCA/CEI

DATE 22 OCT 1979
DR R.H.ARNOLD
APPD
APPD
ENGRG
CHK
APPD
APPD

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

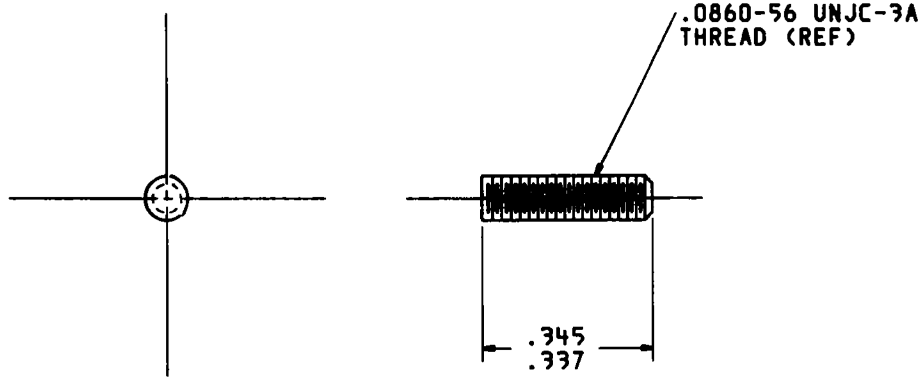
NUT, HEX TYPE A HINGE

SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM1010	
SCALE N/A		SH 1 OF 1	

62-43 SSD4.ANT

REVISIONS

LTR	DESCRIPTION	DATE	APVD



NOTES:

1. 125√ FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.

PARTS LIST

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	STOP	M/F LS8701-2-10			

INTERPRET DWG PER

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR
CCA/CEI

DATE 08 NOV 79
DR R.H.ARNOLD
APPD
APPD
ENGRG
CHK
APPD
APPD

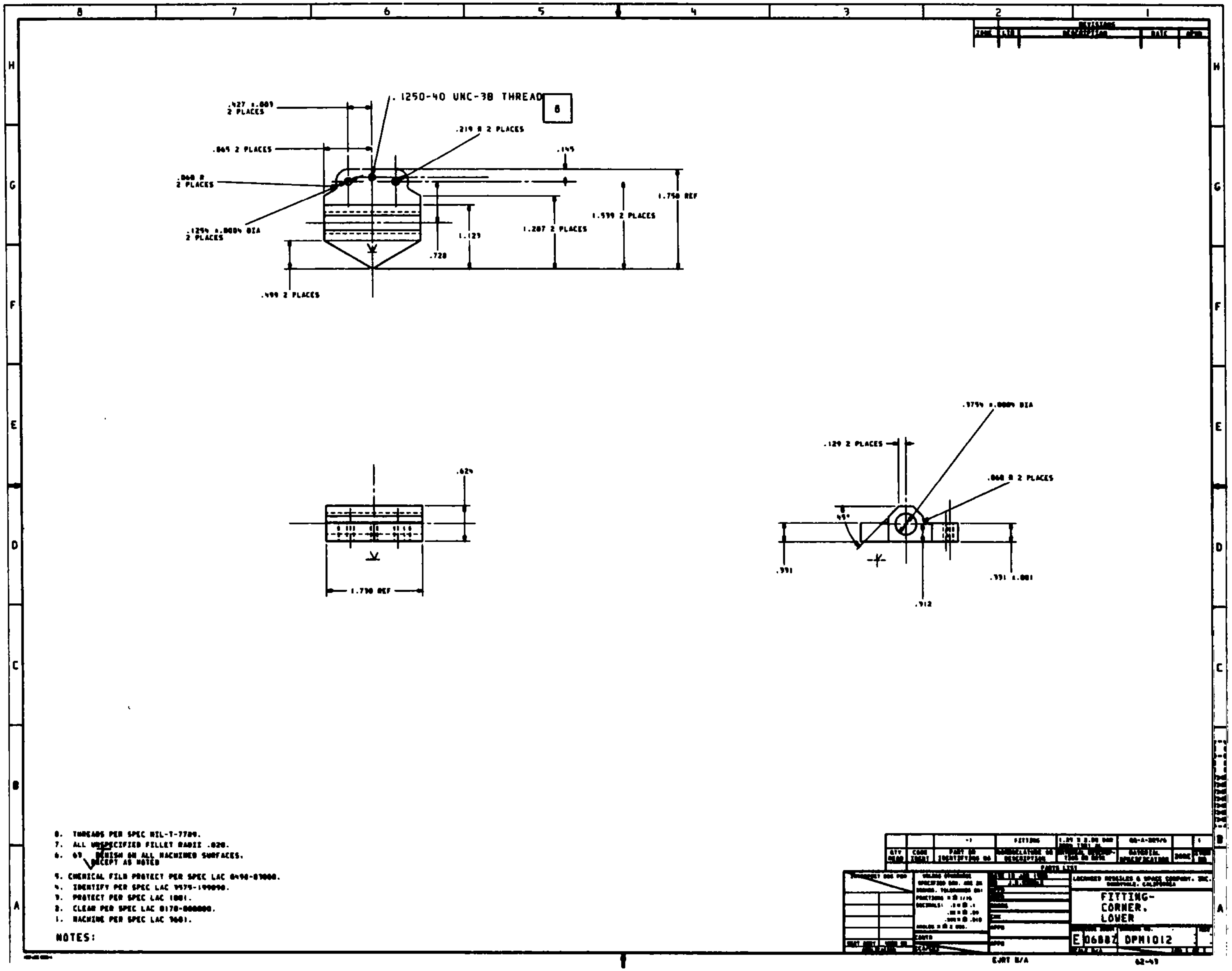
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

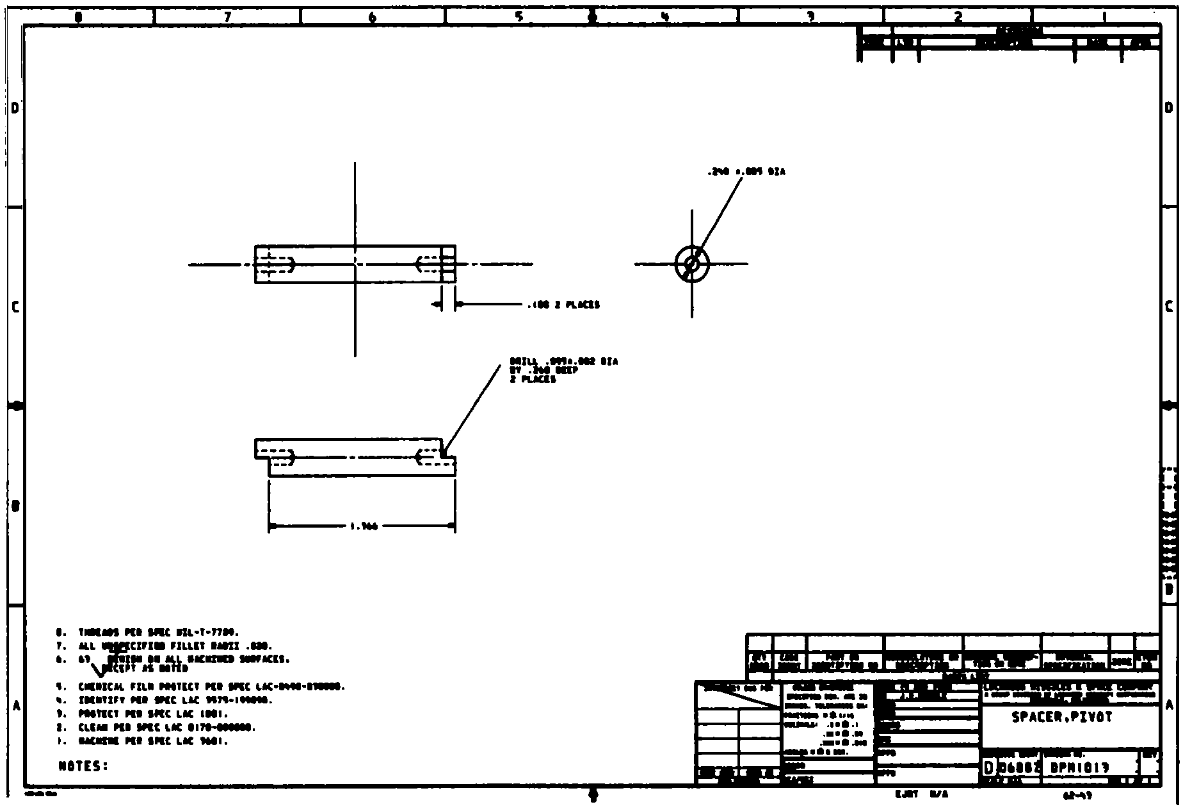
STOP-
ADJUSTABLE

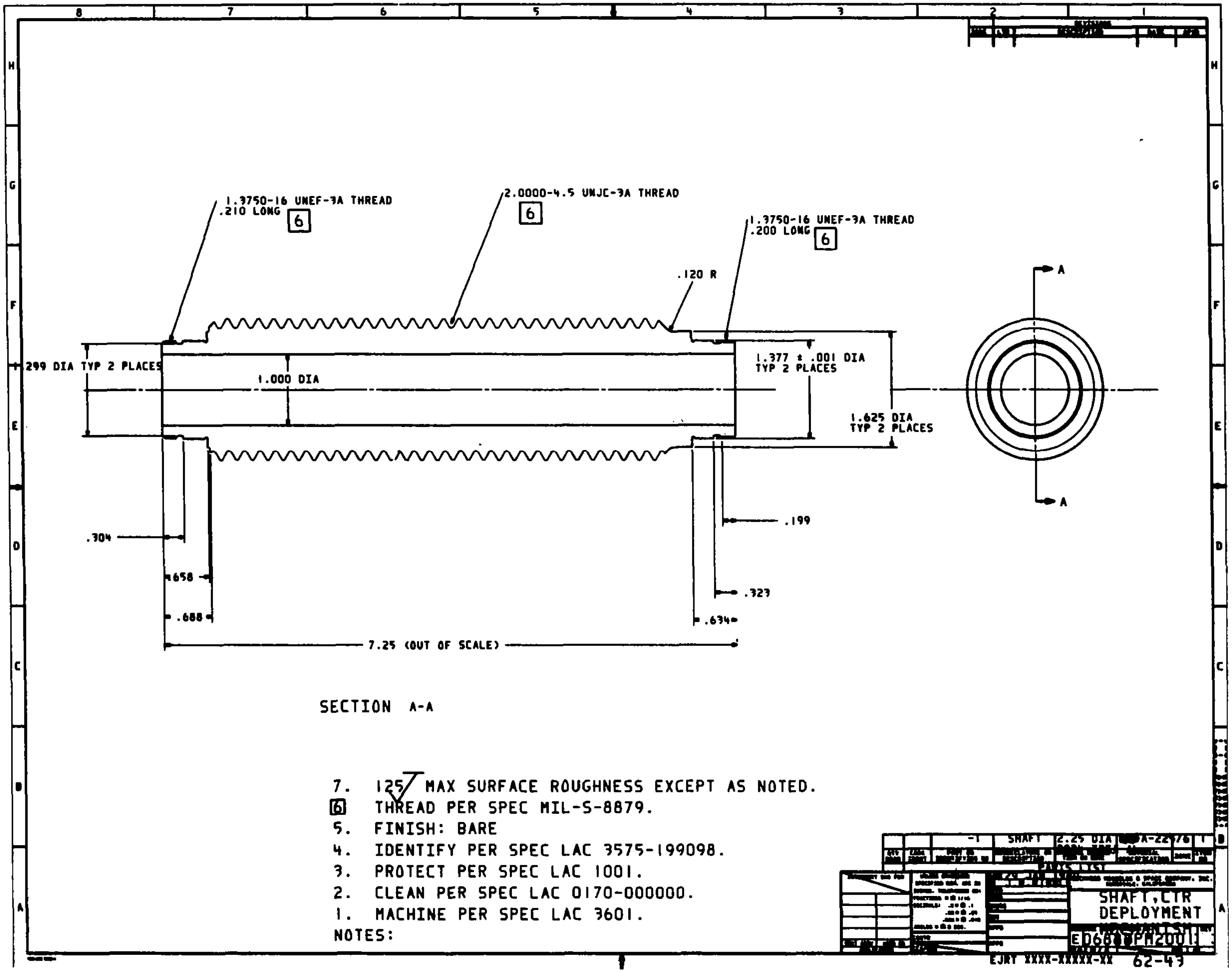
SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM1011	

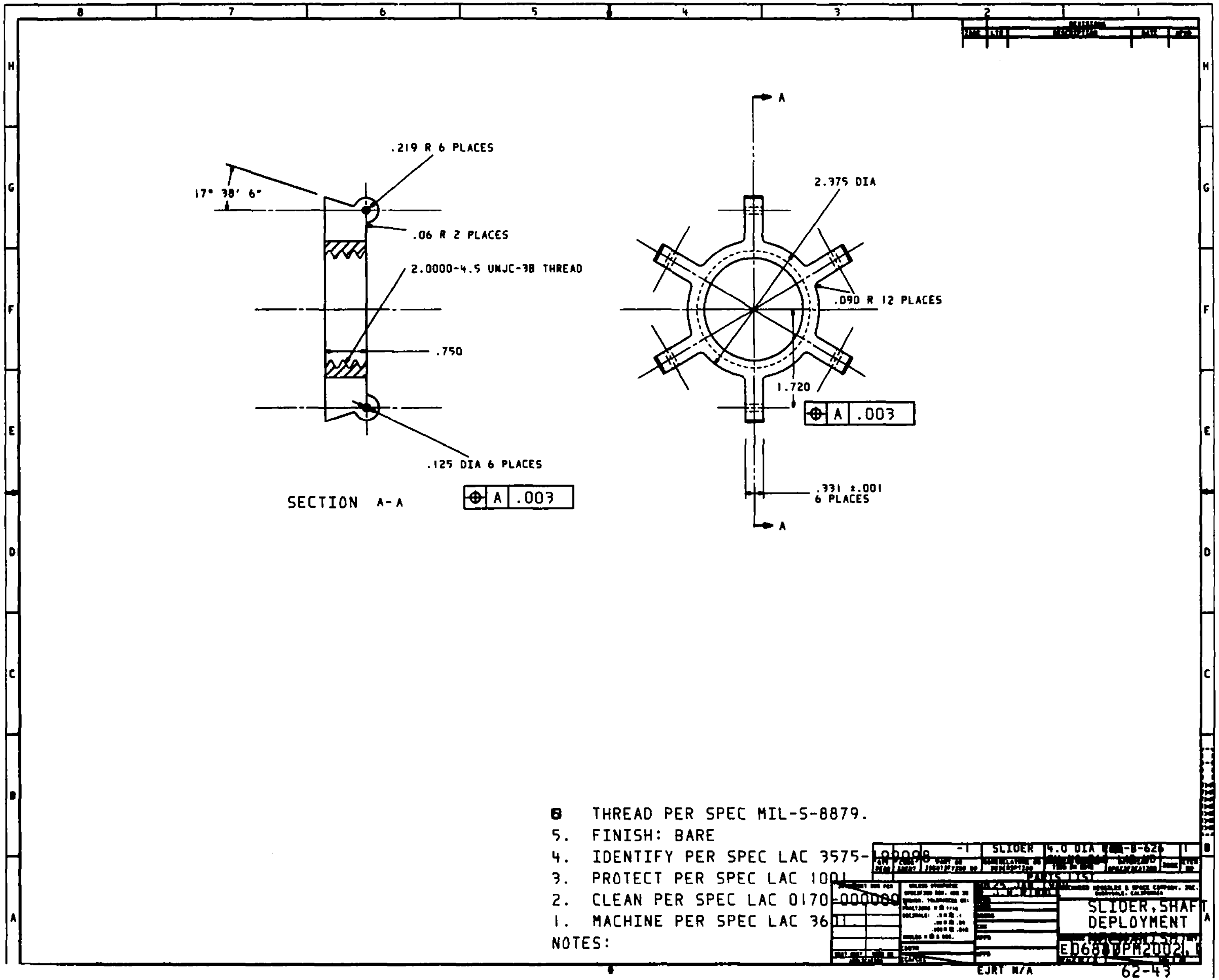
SCALE N/A SH OF

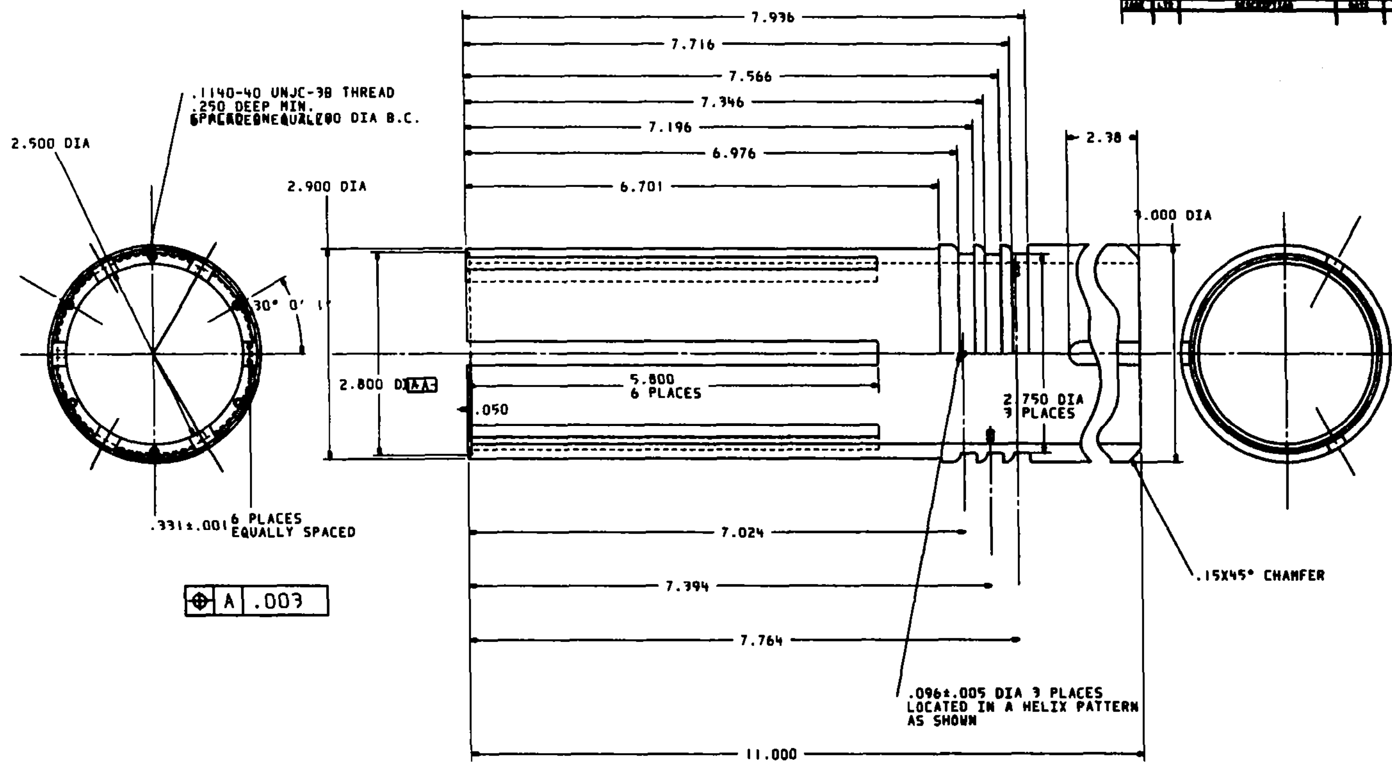
EJRT XXXX-XXXXX-XX 62-43 5504.ANT


.1250-40 UNC-3B THREAD
8
.427 ±.005 2 PLACES
.219 R 2 PLACES
.065 2 PLACES
.145
.060 R 2 PLACES
1.750 REF
1.599 2 PLACES
1.207 2 PLACES
1.125
.1254 ±.0004 DIA 2 PLACES
.728
.499 2 PLACES
.624
1.750 REF
.3754 ±.0004 DIA
.125 2 PLACES
.060 R 2 PLACES
45°
.391
.391 ±.001
.912
8. THREADS PER SPEC MIL-T-7789.
7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES. EXCEPT AS NOTED
5. CHEMICAL FILM PROTECT PER SPEC LAC 0490-07000.
4. IDENTIFY PER SPEC LAC 9575-199090.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 1601.
NOTES:
-1
FITTING
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO
NOMENCLATURE OR DESCRIPTION
MATERIAL SPECIFICATION
ZONE
PARTS LIST
LOCKHEED MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA
FITTING-
CORNER,
LOWER
E 06887 DPM1012
EJRT N/A
62-49


NOTES:
SPACER,PIVOT


1.3750-16 UNEF-3A THREAD
.210 LONG 6
2.0000-4.5 UNJC-3A THREAD 6
1.3750-16 UNEF-3A THREAD
.200 LONG 6
.120 R
1.299 DIA TYP 2 PLACES
1.000 DIA
1.377 ± .001 DIA
TYP 2 PLACES
1.625 DIA
TYP 2 PLACES
A
A
.304
.658
.688
.199
.323
.634
7.25 (OUT OF SCALE)
SECTION A-A
7. 125 MAX SURFACE ROUGHNESS EXCEPT AS NOTED.
6 THREAD PER SPEC MIL-S-8879.
5. FINISH: BARE
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.
NOTES:
-1
SHAFT
2.25 DIA
A-22476
PARTS LIST
SHAFT, CTR
DEPLOYMENT
ED66 PM2001
EJRT XXXX-XXXXX-XX
62-43


.219 R 6 PLACES
17° 38' 6"
.06 R 2 PLACES
2.0000-4.5 UNJC-3B THREAD
.750
.125 DIA 6 PLACES
SECTION A-A
A .003
A
2.375 DIA
.090 R 12 PLACES
1.720
A .003
.331 ±.001
6 PLACES
A
6 THREAD PER SPEC MIL-S-8879.
5. FINISH: BARE
4. IDENTIFY PER SPEC LAC 3575-100098
3. PROTECT PER SPEC LAC 1001
2. CLEAN PER SPEC LAC 0170-000089
1. MACHINE PER SPEC LAC 3601
NOTES:
-1
SLIDER
4.0 DIA
PARTS LIST
SLIDER, SHAFT
DEPLOYMENT
ED68 PM2002
EJRT N/A
62-43



7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-100008
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000009
1. MACHINE PER SPEC LAC 3601.

NOTES:

-1 TUBE 3 O.D.X .25 WALL

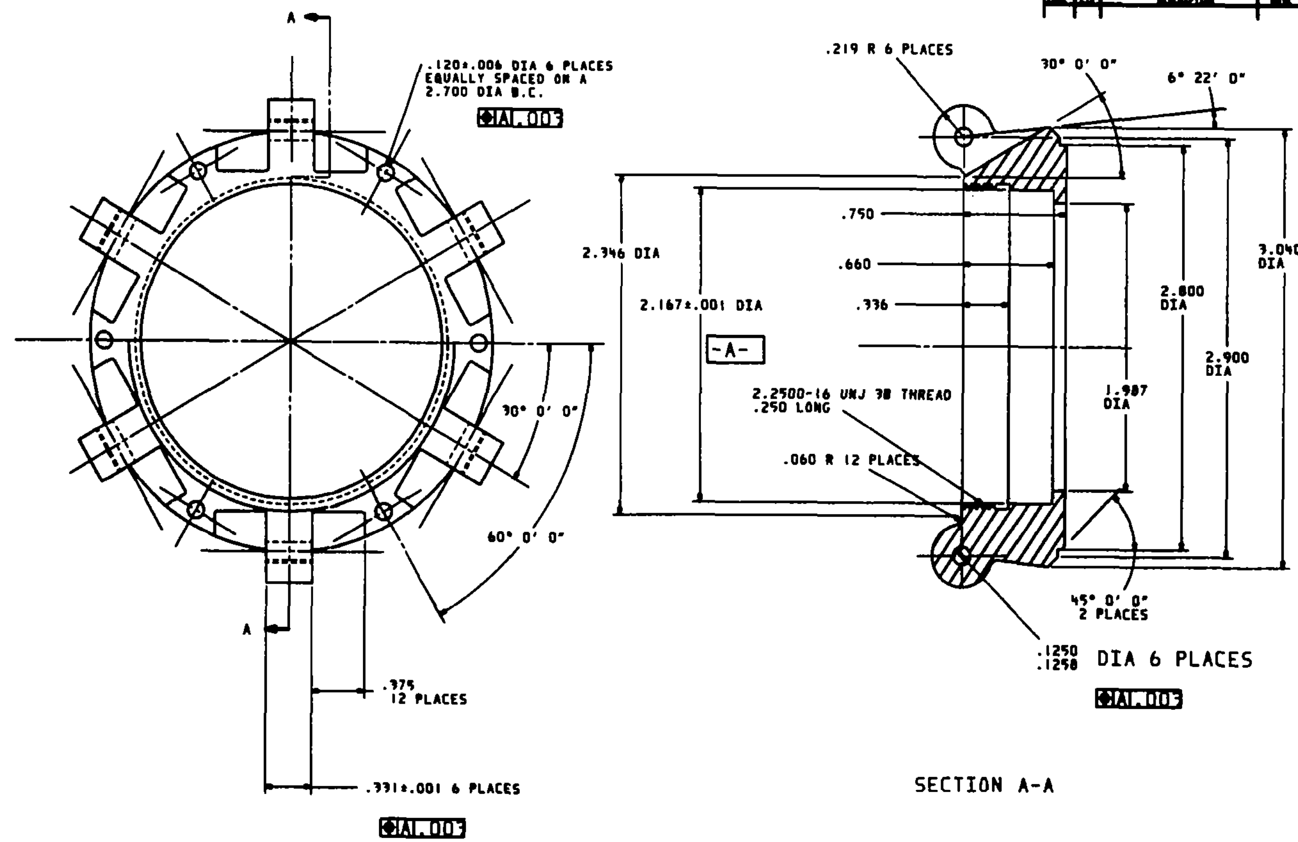
PARTS LIST

TUBE, OUTER, DEPLOYMENT

ED680PM2004

EJRT N/A

62-43



7. ALL UNSPECIFIED FILLET RADII .020.
6. $\sqrt{63}$ FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

-1 FITTING,.5 DIA -A-22

PARTS LIST

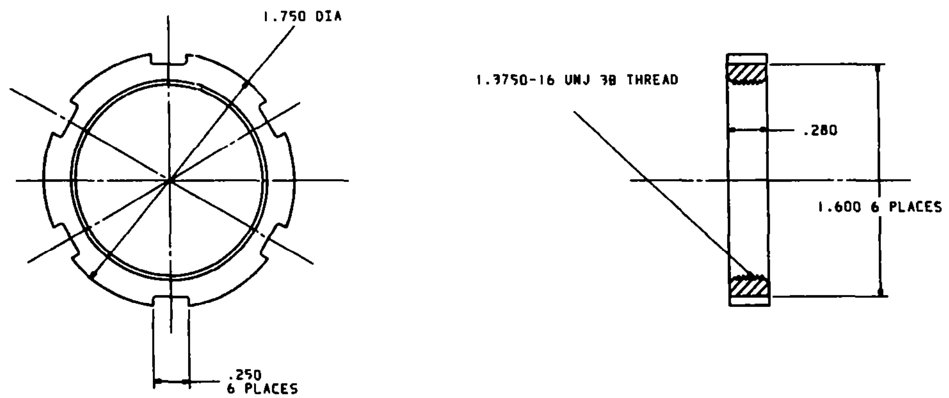
FITTING,UPPE
DEPLOYMENT

ED68 PM2005

EJRT N/A

62-43

171



8. THREADS PER SPEC MIL-T-8879.
7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

		-1	NUT	2.0 DIA ROD			1

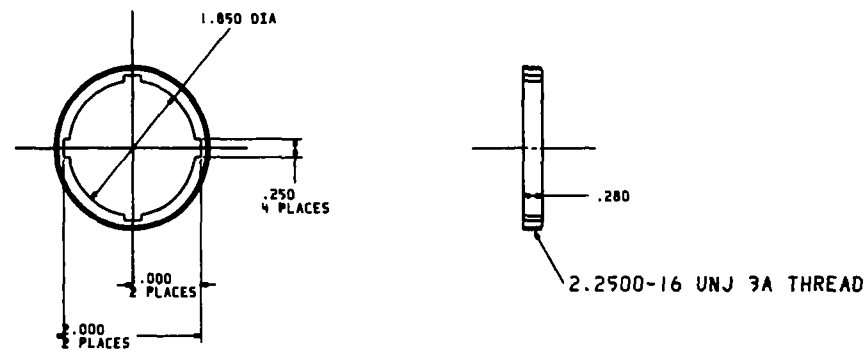
PARTS LIST

NUT, INSIDE DEPLOYMENT

ED680DPM2006

EJRT N/A

62-43



8. THREAD PER SPEC MIL-T-8879.
7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

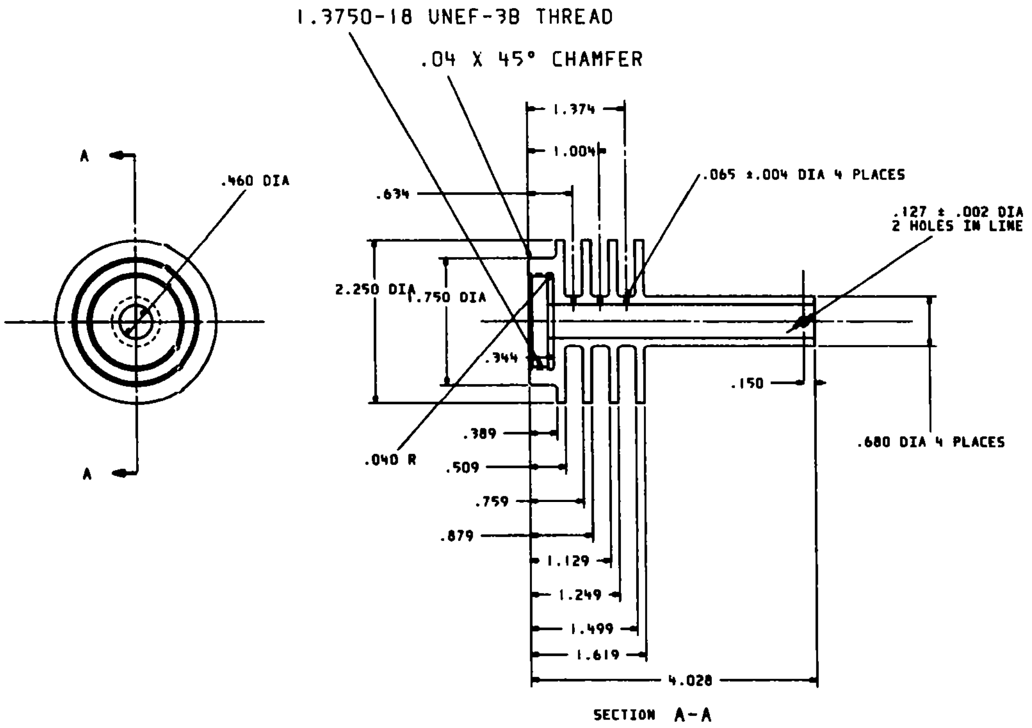
		-1	NUT	2.5 DIA ROD		1

PARTS LIST

NUT, OUTER DEPLOYMENT

DD88[illegible]PM2007

EJRT N/A 62-43



7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

		-1	SPOOL	2.5 DIA	-A-22176	1

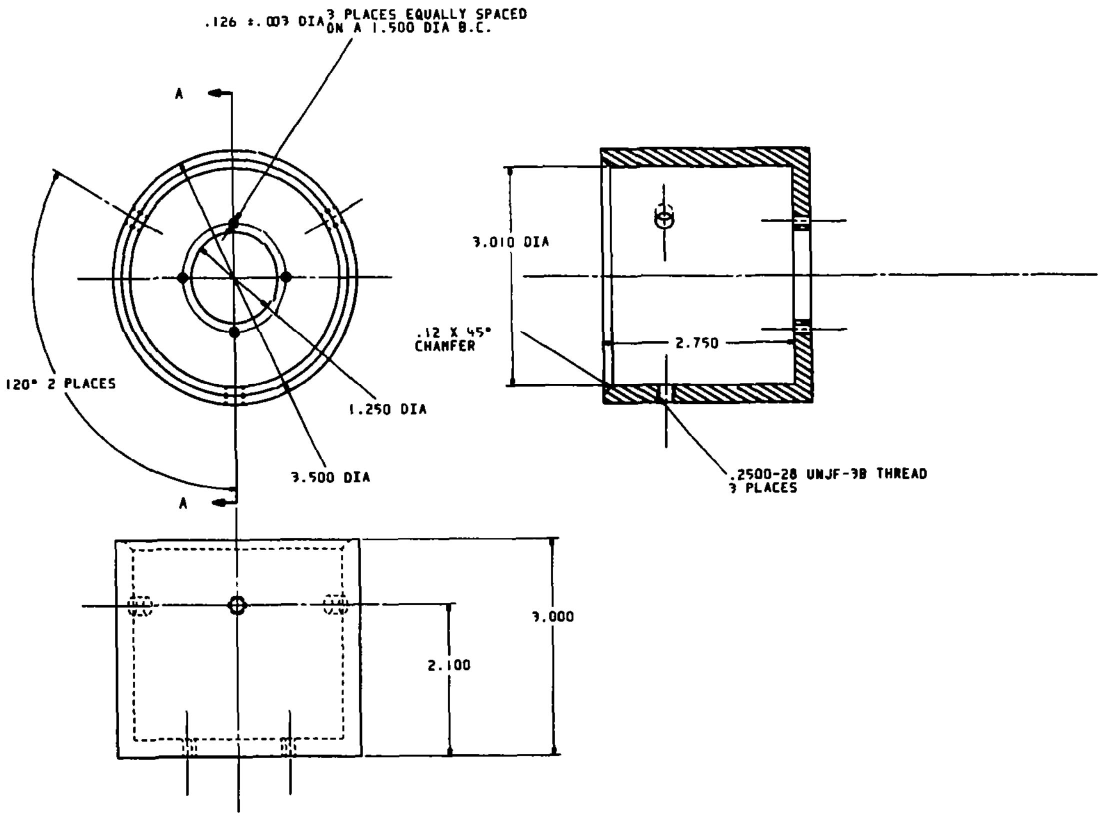
PARTS LIST

SPOOL, CABLE DEPLOYMENT

E06800PM2008

EJRT N/A

62-43



8. THREAD PER MIL-S-8879.
7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

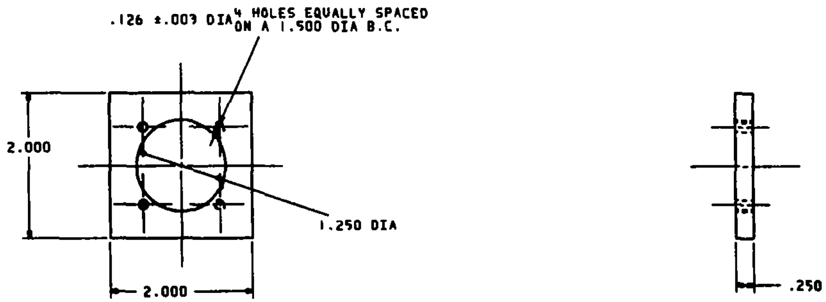
8. THREAD PER MIL-S-8879.
7. ALL UNSPECIFIED FILLET RADII .020.
6. 63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.
NOTES:

PARTS LIST

CUP, MOUNTING
DEPLOYABLE

ED6810PM2009

EJRY XXXX-XXXXX-XX 62-43



7. ALL UNSPECIFIED FILLET RADII .020.
6. √63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

PARTS LIST

PLATE, ADAPTER DEPLOYABLE

ED6800PM2010

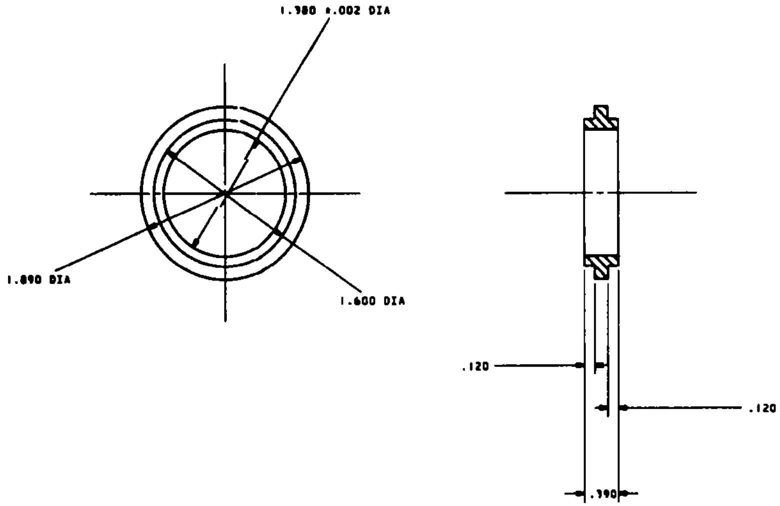
EJRY N/A

62-43

REVISION STATUS OF SHEETS	REV				
	SHEET	1	2	3	4

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APVD



7. ALL UNSPECIFIED FILLET RADII .015.
6. 63 FINISH ON ALL MACHINED SURFACES. EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	RACE	2.00 DIA ROD CU NO 360			1

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS ± 1/16 DECIMALS: .X ± .1 .XX ± .03 .XXX ± .010 ANGLES ± 2 DEG.

LOCKHEED MISSILES & SPACE COMPANY

BEARING, UPPER INNER RACE

D 06887 DPM2011

EJRT N/A

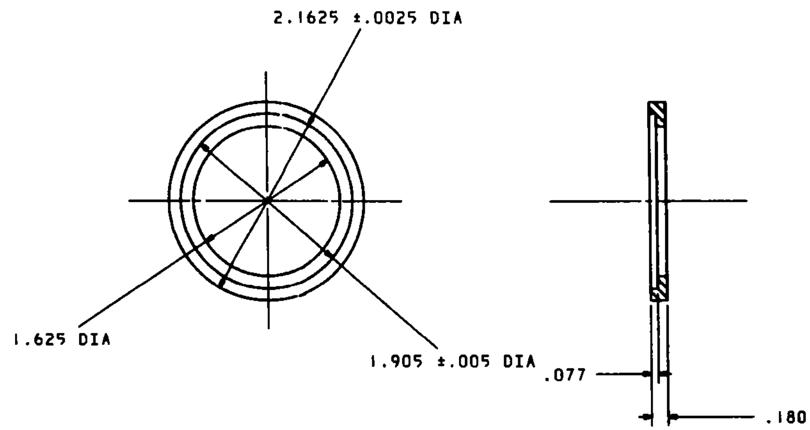
62-43

REVISION STATUS OF SHEETS

REV				
SHEET	1	2	3	4

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APVD



7. ALL UNSPECIFIED FILLET RADII .015.
6. √63 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	RACE	2.00 DIA ROD TEFLON			1

PARTS LIST

DATE 24 FEB 19[illegible]

J. W. RIBBL[illegible]

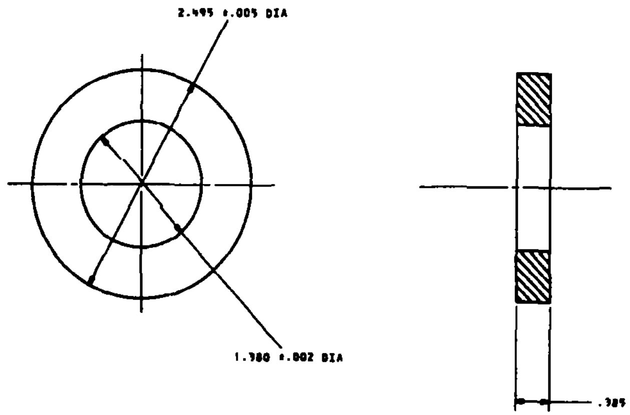
LOCKHEED MISSILES & SPACE COMPANY

BEARING, UPPER OUTER RACE

D D6880PM2012

EJRT N/A

62-43



7. ALL UNSPECIFIED FILLET RADII .015.
6. 63 $\sqrt{}$ FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC 0498-030000.
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.

NOTES:

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	RACE	2.50 DIA ROD TEFLON			1

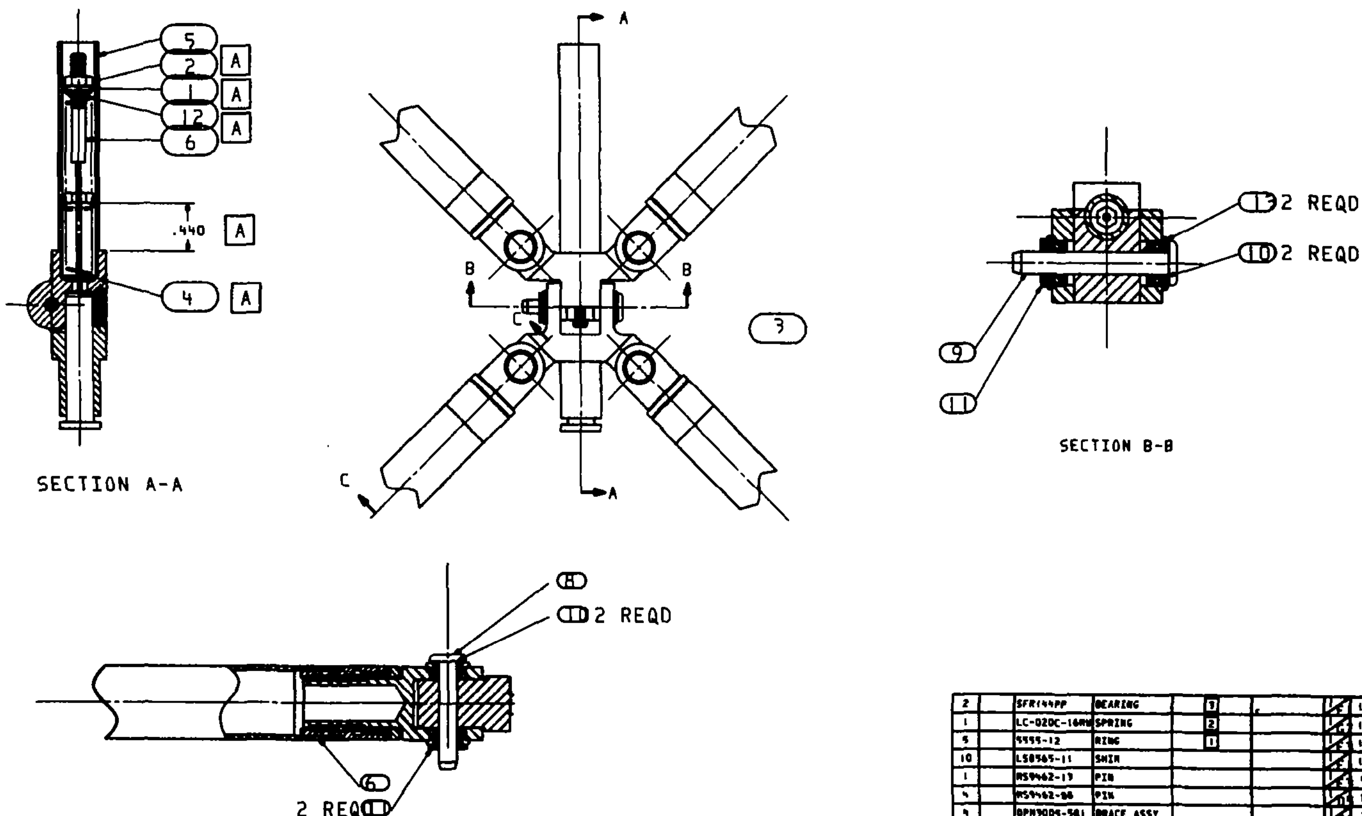
PARTS LIST

BEARING, LOWER

D 06887 DPM2013

EJRT N/A

62-43



4 TO ADJUST SPRING, ITEM 12, FOLD HINGE AND TIGHTEN NUT, ITEM 2, TO ACHIEVE DESIRED CLEARANCE BETWEEN RETAINER, ITEM 1, AND PIVOT, ITEM 4.

3 NEW HAMPSHIRE BALL BEARINGS INC. PETERSBOROUGH, N.H. 03458

2 LEE SPRING CO., BROOKLYN, N.Y. 11201.

1 WALDES KOHINOOR, INC., LONG ISLAND, N.Y. 11101.

NOTES:

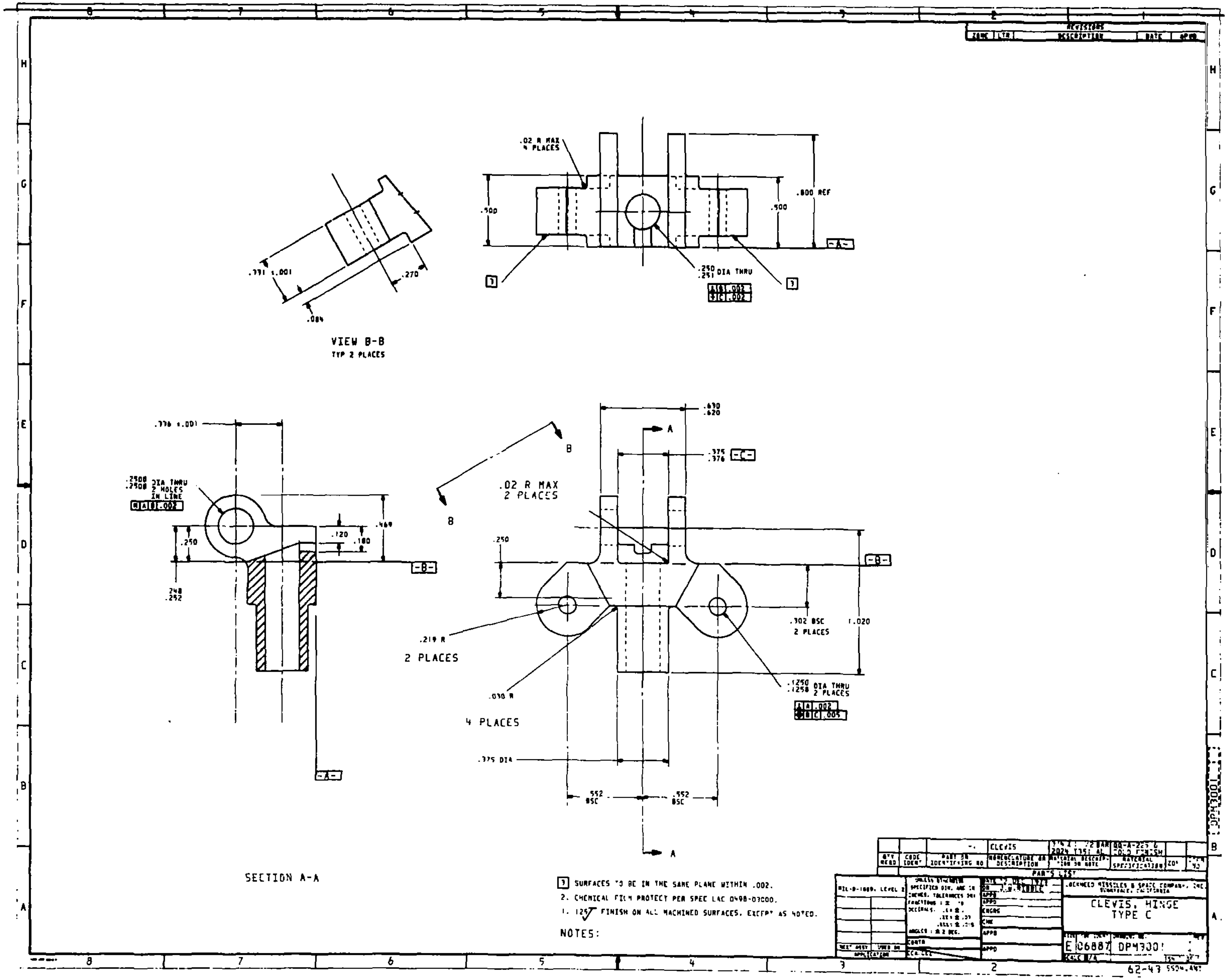
QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	[illegible]	MATERIAL SPECIFICATION	ZONE	ITEM NO
2		SFR144PP	BEARING	3			13
1		LC-020C-16MW	SPRING	2			12
5		5555-12	RING	1			11
10		LS0565-11	SHIM				10
1		MS9462-13	PIN				9
4		MS9462-08	PIN				8
4		DPM3005-501	BRACE ASSY				7
1		DPM3004-501	LATCH ASSY				6
1		DPM3003-1	TUBE				5
1		DPM3002-1	PIVOT				4
1		DPM3001-1	CLEVIS				3
1		DPM1810-1	NUT				2
1		DPM1008-1	RETAINER				1

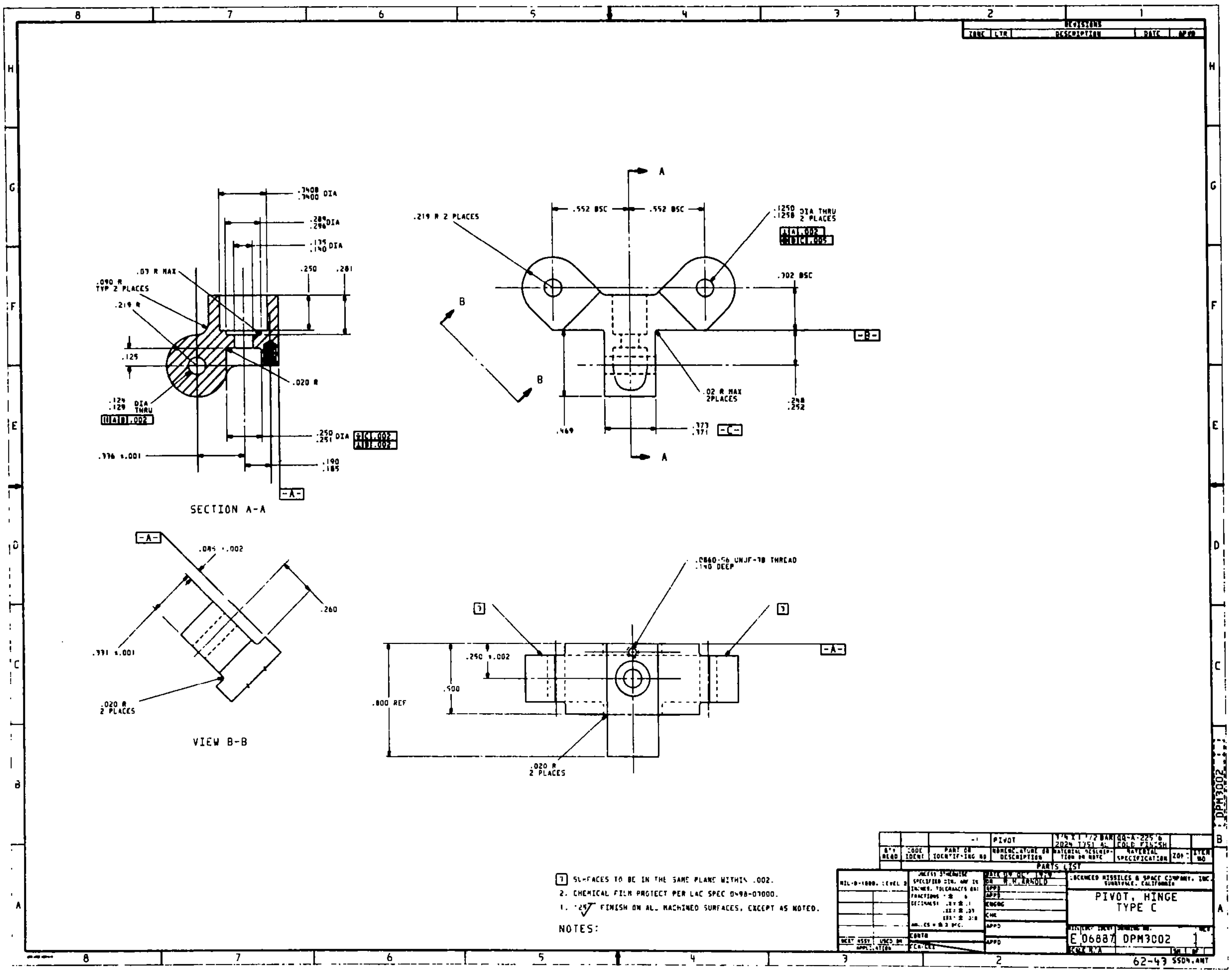
PARTS LIST

HINGE ASSEMBLY
TYPE C

ED68 0PM3000

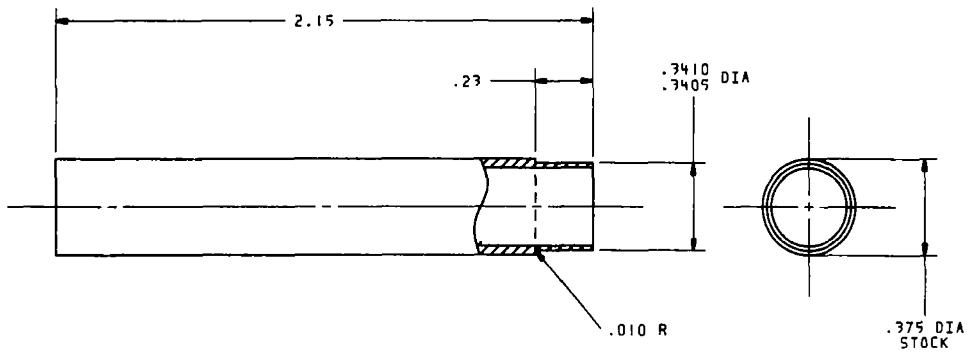
62-45504.ANT


VIEW B-B
TYP 2 PLACES
.02 R MAX
4 PLACES
.800 REF
.500
.270
.084
.250
.251 DIA THRU
.02 R MAX
2 PLACES
.630
.620
.375
.376
.250
.219 R
2 PLACES
.030 R
4 PLACES
.302 BSC
2 PLACES
1.020
.1250
.1258 DIA THRU
2 PLACES
.375 DIA
.552
BSC
SECTION A-A
3 SURFACES TO BE IN THE SAME PLANE WITHIN .002.
2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.
1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
NOTES:
CLEVIS
PARTS LIST
CLEVIS, HINGE
TYPE C
E 06887 DPM3001
62-43


SECTION A-A
VIEW B-B
.3408 .3400 DIA
.250 .251 DIA
.020 R
2 PLACES
.219 R 2 PLACES
.552 BSC
.1250 .1258 DIA THRU 2 PLACES
.302 BSC
.02 R MAX 2PLACES
.469
.0860-56 UNJF-3B THREAD .140 DEEP
.250 ±.002
.500
.800 REF
.260
.331 ±.001
.336 ±.001
3 SURFACES TO BE IN THE SAME PLANE WITHIN .002.
2. CHEMICAL FILM PROTECT PER LAC SPEC 0498-07000.
1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
NOTES:
PIVOT
2024 T351 AL
QQ-A-225/6 COLD FINISH
PARTS LIST
LOCKHEED MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA
PIVOT, HINGE
TYPE C
E 06887 DPM3002
62-43

ZONE	LTR	DESCRIPTION	DATE	APVD

REVISIONS



		-1	TUBE	3/8 X .035 W TUBE 2024 AL	WW-T-700/3 TEM T3 TYPE I		
QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO

PARTS LIST

NOTES:

1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.

MIL-D-1000, LEVEL 2

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR
CCA/CEI

DATE 16 OCT 1979
DR R.H.ARNOLD
APPD
APPD
ENGRG
CHK
APPD
APPD

LOCKHEED MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA

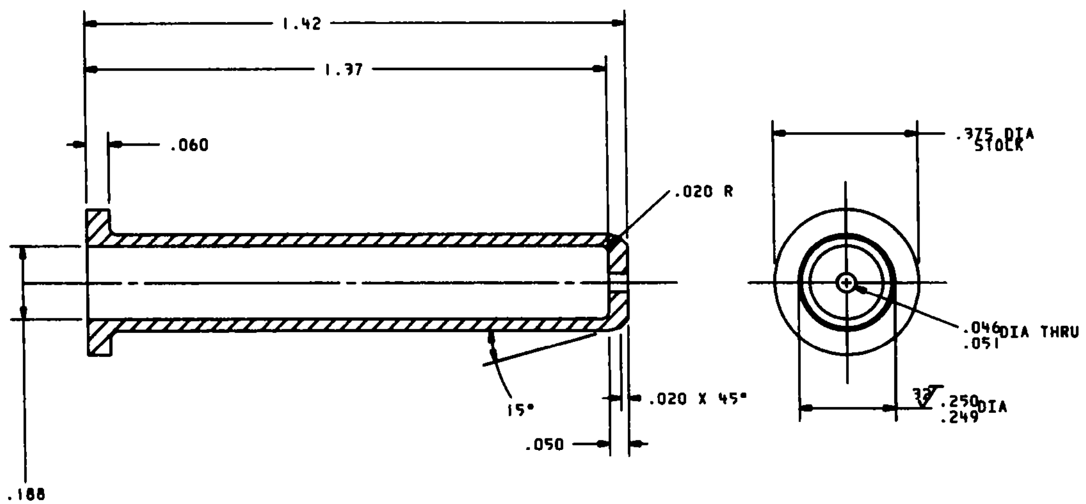
TUBE,
TYPE C HINGE

SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM3003	
SCALE N/A		SH 1 OF 1	

DPM3003

62-43 5504,ANT

LTR	REVISIONS DESCRIPTION	DATE	APVD



DPM3004

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
		-1	LATCH	3/8 DIA ROD 2024 T4 AL	QQ-A-225/6 COLD FINISH		

PARTS LIST

2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-03000.

1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.

NOTES:

INTERPRET DWG PER MIL-D-1000, LEVEL 2

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS = ± 1/16
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES = ± 2 DEG.

CONTR

CCA/CEI

DATE	6 OCT 1979
DR	R.H.ARNOLD
APPD	
APPD	
ENGRG	
CHK	
APPD	
APPD	

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

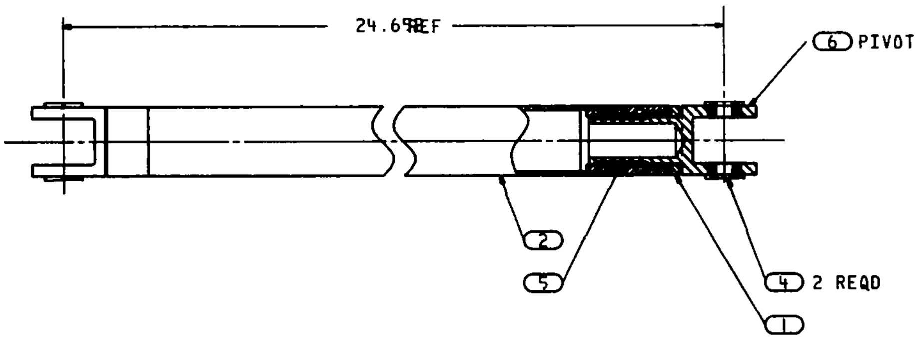
LATCH
TYPE C HINGE

SIZE	CODE IDENT	DRAWING NO.	REV
C	06887	DPM3004	

SCALE N/A | SH 1 OF 1

62-43 SSD4.ANT

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APVD



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL DESCRIPTION OR NOTE	MATERIAL SPECIFICATION	ZONE	ITEM NO
1		DPM3007-	PIVOT				6
1		5L7-D, T	BUSHING	2			5
2		SFR144PP	BEARING	1			4
1		DPM3006-	PIVOT				3
1		DPM1004-	BEAM				2
2		DPM1003-	NUT				1

-501 PARTS LIST

2 NEW HAMPSHIRE BALL BEARINGS INC., PETERBOROUGH, N.H. 03458.

1 THOMPSON INDUSTRIES, INC., MANHASSET, N.Y. 11030

NOTES:

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16 DECIMALS: .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES = ± 2 DEG.

DATE 15 OCT 19

DR R. H. ARNOLD

LOCKHEED MISSILES & SPACE COMPANY

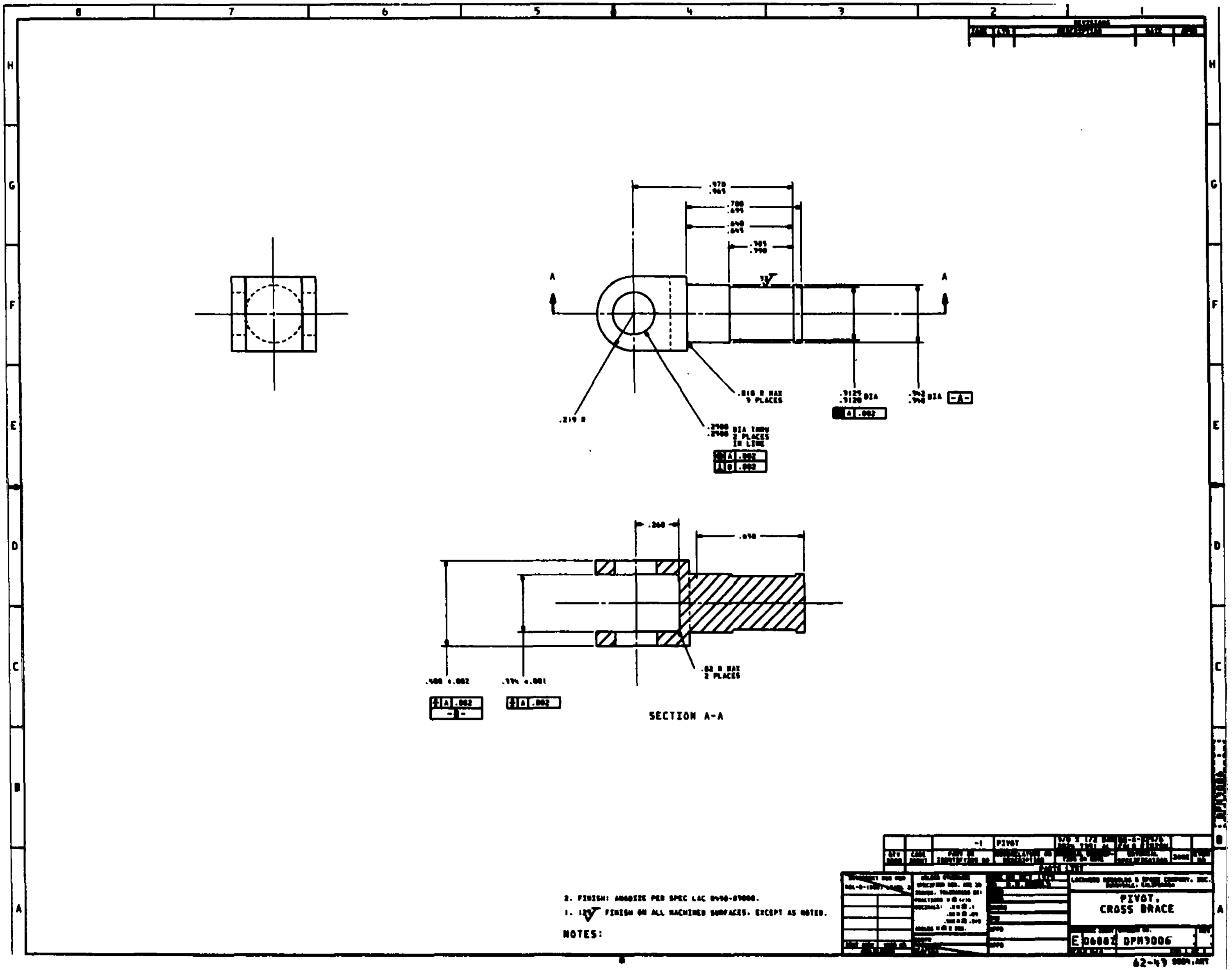
BRACE ASSEMBL

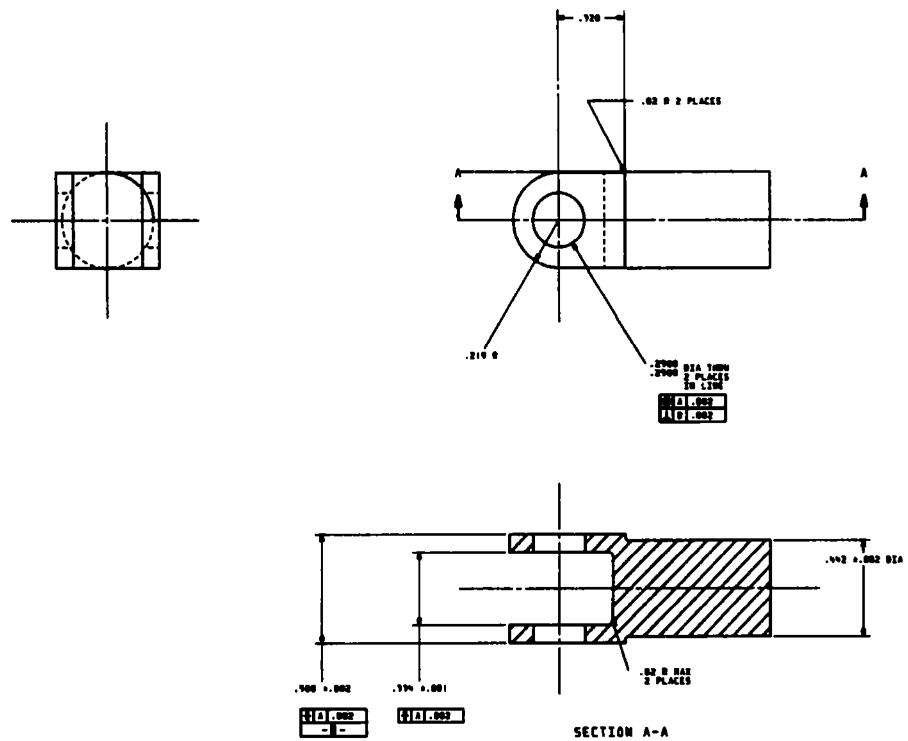
CROSS,

DPM3005

SCALE N/A

62-46904.ANT


SECTION A-A
2. FINISH: ANODIZE PER SPEC LAC 0490-09000.
1. 125 FINISH ON ALL MACHINED SURFACES. EXCEPT AS NOTED.
NOTES:
PIVOT
PIVOT,
CROSS BRACE
E
DPM3006
62-49



NOTES:

1. 125√ FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.

2. FINISH: ANODIZE PER SPEC LAC 0490-93000.

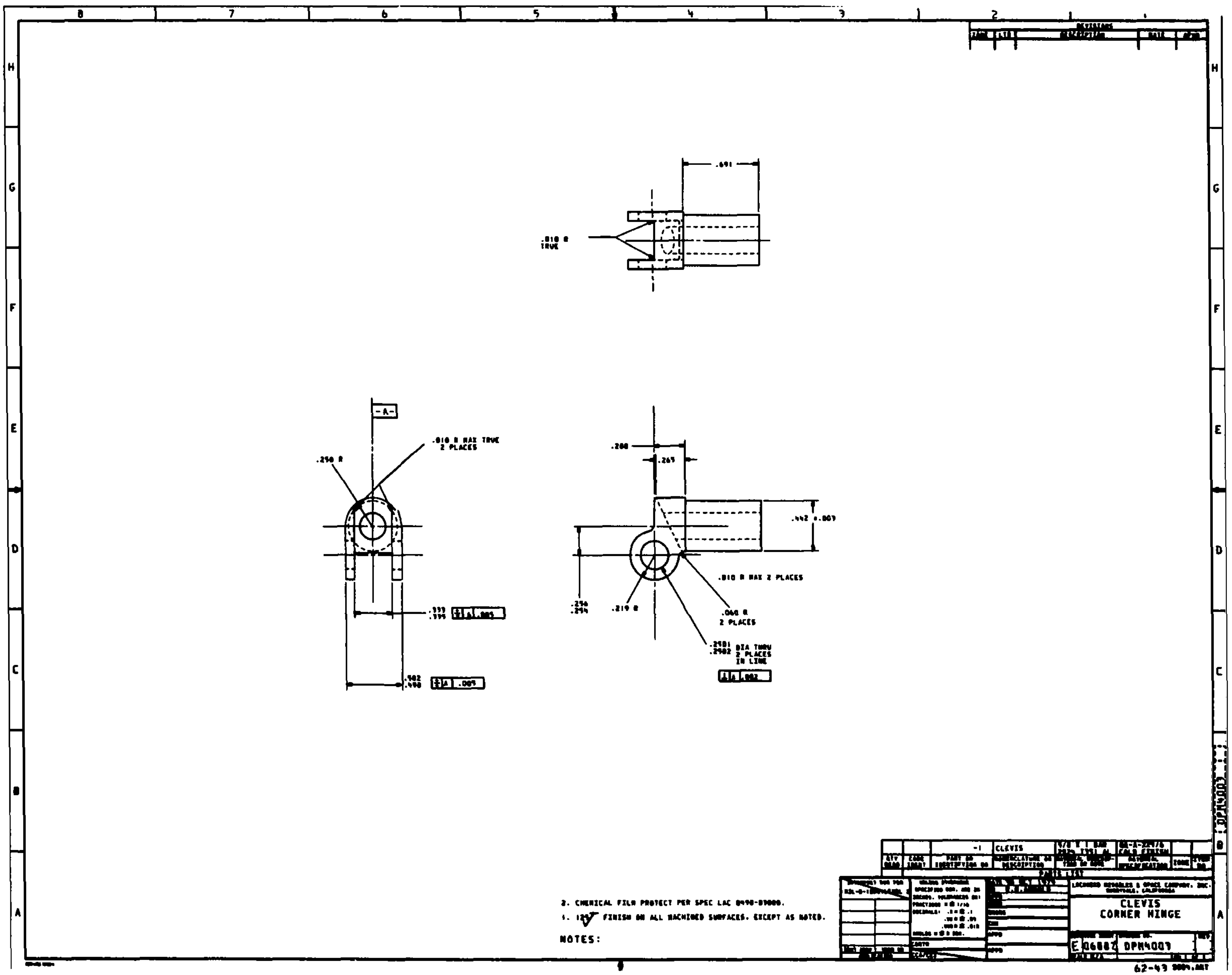
-1 PIVOT

PARTS LIST

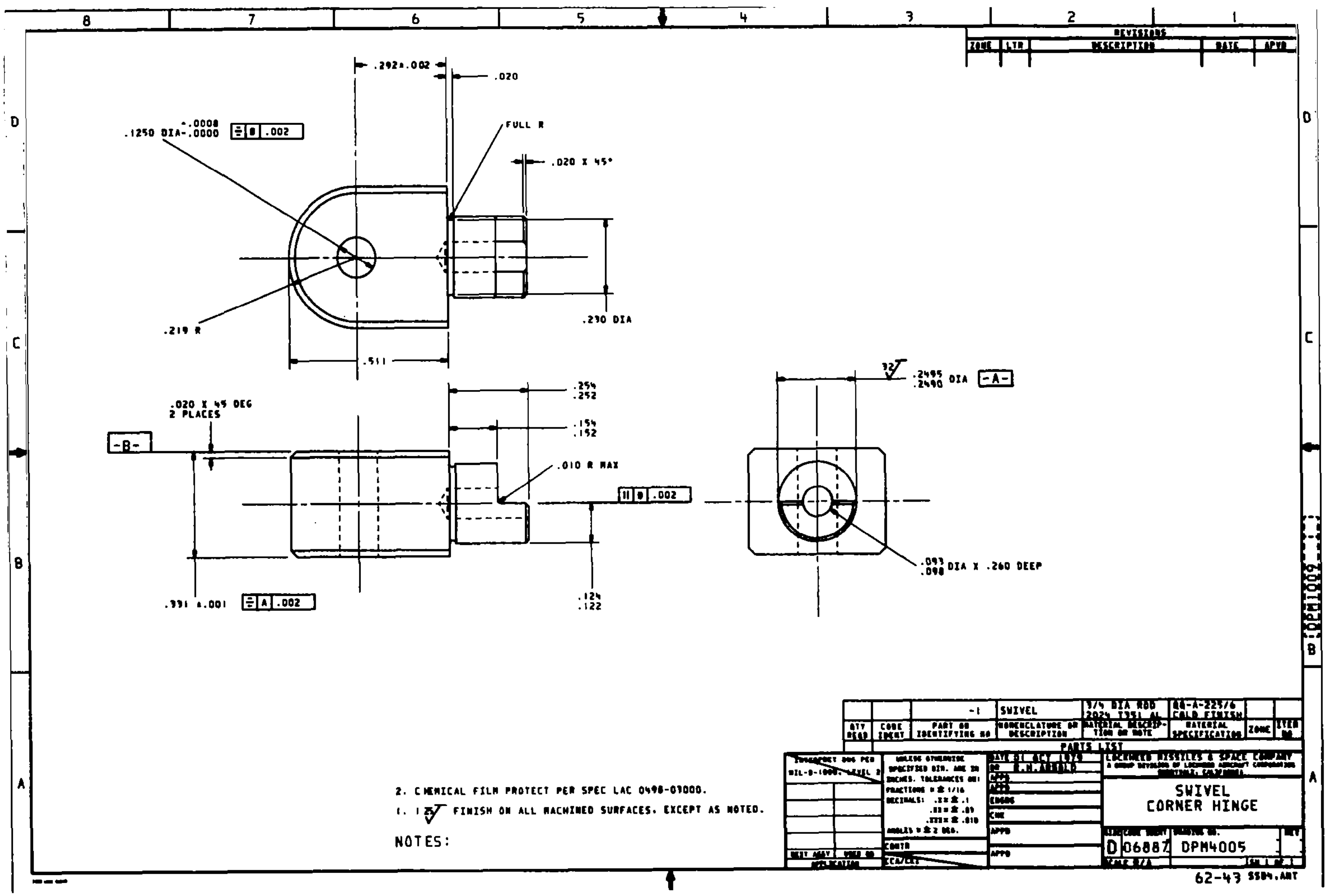
PIVOT, CROSS BRACE, THREADED

E 06887 DPM3007

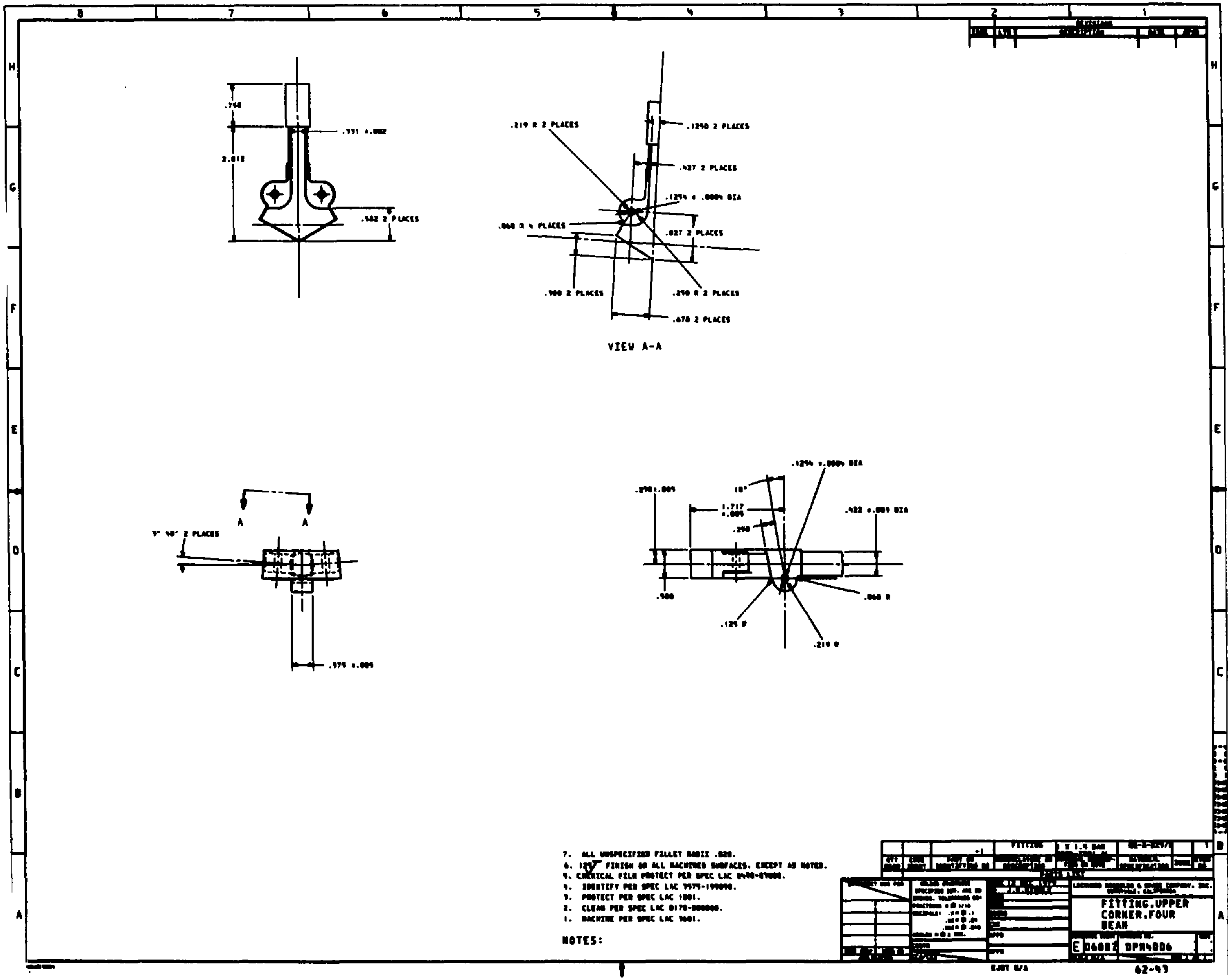
62-43

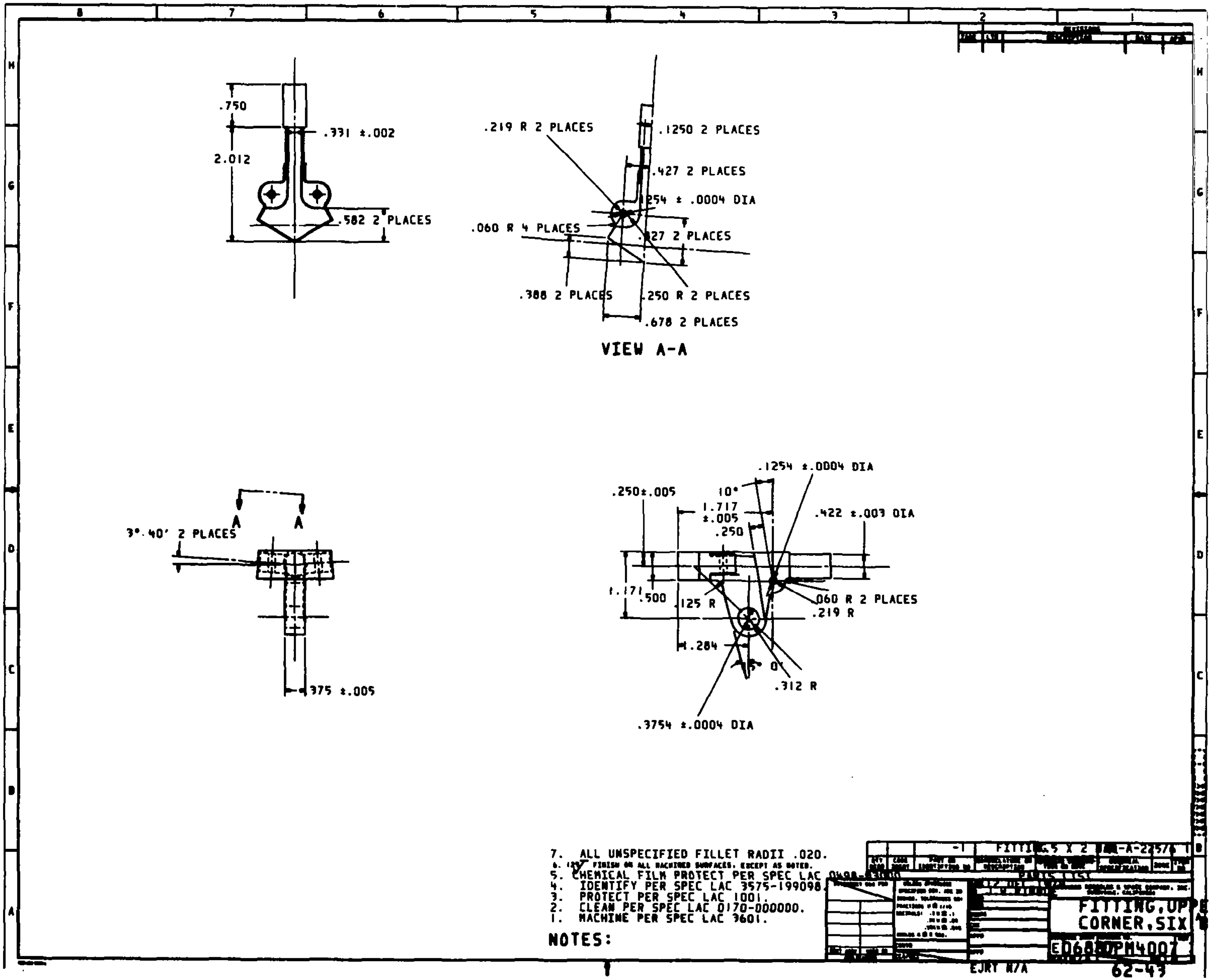


-A-
.010 R MAX TRUE 2 PLACES
.250 R
.010 R TRUE
.200
.265
.442 ±.003
.010 R MAX 2 PLACES
.219 R
.060 R 2 PLACES
DIA THRU 2 PLACES IN LINE
-1
CLEVIS
PARTS LIST
LOCKHEED MISSILES & SPACE COMPANY, INC.
CLEVIS
CORNER HINGE
E 06887 DPM4007
62-43
2. CHEMICAL FILM PROTECT PER SPEC LAC 0490-09000.
1. 125 FINISH ON ALL MACHINED SURFACES. EXCEPT AS NOTED.
NOTES:



REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APVD
.292±.002
.020
FULL R
+.0008
.1250 DIA -.0000
.002
.020 X 45°
.219 R
.230 DIA
.511
.2495
.2490 DIA
-A-
.254
.252
.020 X 45 DEG
2 PLACES
.154
.152
-B-
.010 R MAX
.002
.093
.098 DIA X .260 DEEP
.391 ±.001
A
.002
.124
.122
2. CHEMICAL FILM PROTECT PER SPEC LAC 0498-07000.
1. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
NOTES:
-1
SWIVEL
3/4 DIA ROD
2024 T351 AL
COLD FINISH
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO
NOMENCLATURE OR DESCRIPTION
MATERIAL DESCRIPTION OR NOTE
MATERIAL SPECIFICATION
ZONE
ITEM NO
PARTS LIST
UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON:
FRACTIONS
1/16
DECIMALS: .XX
.1
.XXX
.010
ANGLES
2 DEG.
CONTR
APPD
ENGRG
CHK
APPD
APPD
LOCKHEED MISSILES & SPACE COMPANY
SWIVEL
CORNER HINGE
D
06887
DPM4005
SCALE N/A
62-43 SS04.ART


VIEW A-A
7. ALL UNSPECIFIED FILLET RADII .020.
6. 125 FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC
4. IDENTIFY PER SPEC LAC
3. PROTECT PER SPEC LAC
2. CLEAN PER SPEC LAC
1. MACHINE PER SPEC LAC 9601.
NOTES:
FITTING, UPPER CORNER, FOUR BEAM
DPM4806
62-49



.750
.331 ±.002
2.012
.582 2 PLACES
.219 R 2 PLACES
.1250 2 PLACES
.427 2 PLACES
.1254 ± .0004 DIA
.060 R 4 PLACES
.427 2 PLACES
.388 2 PLACES
.250 R 2 PLACES
.678 2 PLACES
VIEW A-A
A
A
3°.40' 2 PLACES
.375 ±.005
.1254 ±.0004 DIA
.250±.005
10°
1.717 ±.005
.422 ±.003 DIA
.250
1.171
.500
.125 R
.060 R 2 PLACES
.219 R
.284
0°
.312 R
.3754 ±.0004 DIA
7. ALL UNSPECIFIED FILLET RADII .020.
6. FINISH ON ALL MACHINED SURFACES, EXCEPT AS NOTED.
5. CHEMICAL FILM PROTECT PER SPEC LAC
4. IDENTIFY PER SPEC LAC 3575-199098.
3. PROTECT PER SPEC LAC 1001.
2. CLEAN PER SPEC LAC 0170-000000.
1. MACHINE PER SPEC LAC 3601.
NOTES:
FITTING, UPPER
CORNER, SIX
EJRT N/A
62-43

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-3316		

4. Title and Subtitle	5. Report Date
MODULAR ANTENNA DESIGN STUDY	September 1981
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
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16. Abstract

This report documents a study which researched the mechanical design of a modular antenna using a particular deployable module concept. The design was developed sufficiently to allow manufacture of a working demonstration model of a module, and to predict mass properties and to make performance estimates for antenna reflectors composed of these modules.

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